THE EFFECT OF SELECTED TEACHING METHODS ON ACQUISITION OF TECHNICAL SKILLS BY MECHANICAL ENGINEERING TECHNICIAN TRAINEES: A CASE OF NATIONAL POLYTECHNICS IN THE WESTERN REGION OF KENYA

BY

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JULY, 2022

DECLARATION

DECLARATION BY THE STUDENT

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DEDICATION

I dedicate this thesis to my family and my friends. I have a special feeling of gratitude to my loving parents Elijah O. Migiro and Agnes Gesare and secondly, to my children; Edgar, Steve, Danvas and Brandon.

ABSTRACT

The right approach to teaching and evaluation of practical subjects in technical colleges is crucial in imparting practical skills and adequate creative power to students in order to meet the requisite human resource skills needed in achieving Sustainable Development Goals (SDGs2016-2030), through technical and vocational education and training (TVET). Teaching methods can affect the acquisition of technical skills by mechanical engineering students in national polytechnics. In this study, the effect of teaching methods on the acquisition of technical skills in three TVET institutions in Western Kenya was assessed. The study was governed by the following specific objectives; (i). determine the effect of work-based teaching on the acquisition of technical skills, (ii). examine the effect of tutorials on the acquisition of technical skills, (iii). evaluate the effect of problem-based teaching on the acquisition of technical skills, (iv). assess the effects of project-based teaching on the acquisition of technical skills, (v). evaluate the effect of workshop teaching on the acquisition of technical skills for mechanical engineering students in national polytechnics in the western Kenya region and (vi) evaluate the combined effect of work-based, tutorials, problem-based learning, project-based and workshop training in national polytechnics in western Kenya region. An explanatory research design was used to assess potential challenges/problems associated with the different teaching methods in a random sample of mechanical engineering trainees (248) and trainers (66) in three (Kisii, Kisumu and Sigalagala) national polytechnics in western Kenyan region. Data was collected using structured questionnaires which were self-administered. Inferential and descriptive analysis of data was done by application of SPSS version 25.0. From the results of this research, multiple regressions indicated that teaching methods jointly and independently affected the acquisition of technical skills in mechanical engineering in national polytechnics. A mix of all five teaching methods showed a positive significant effect of 67.1% in the acquisition of technical skills with a beta value of 0.178 for work-based learning, 0.134 for tutorials, 0.164 for problem-based learning, 0.200 for project-based learning and 0.176 for workshop training method. No single method, when used alone was adequate in imparting practical skills to students. The findings imply that national polytechnics should embrace an array of teaching methods complemented by other approaches such as virtual learning and computer-aided learning and proactively formulate policies and resources which support the teaching methods above to improve the acquisition of technical skills among mechanical engineering students.

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ABBREVIATIONS, AND ACRONYMS

ANOVA	Analysis of Variance
CLT	Cognitive Learning Theory
ETF	European Training Foundation
Hods	Heads of departments
ICT	Information Communication and Technology
ILO	International Labour Organization
KNEC	Kenya National Examinations Council
MRA	Multiple Regression Analysis
NACOSTI	National Commission for Science, Technology and Innovation
PBL	Problem-Based Learning
SIWES	Student Industrial Work Experience Scheme
SLRA	Simple Linear Regression Analysis
TEVT	Technical and Vocational Education and Training
TTIs	Technical Training Institutes
TVTET	Technical and Vocational Teacher Education and Training
TWA	Tutoring with Alphine
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNEVOC	International Centre for Technical and Vocational Education and Training
VET	vocational education and training
WBL	Work-Based Learning

LIST OF SYMBOLS

N	Total sample size
ε	Epsilon, true experimental error
df	Degree of freedom
t	Students t test for independent variables
M	Mean
SD	Standard deviation of a sample
f	Frequency
β	Population regression coefficient
CV	Coefficient of variation
R^2	Coefficient of determination
CI	Confidence interval
n	Size of subsample

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CHAPTER ONE

INTRODUCTION

This chapter gives details about the research by making close reference to; the background of the research, problem statement, research objectives as well as the research questions. The chapter also explains the meaning and significance of dependent and independent variables. Relevant published works have been referenced. The scope of the study, conceptual framework and theoretical frameworks have also been discussed.

1.1 Background of the study

World over, the interest of vocational education is to enable trainees to do things according to standards and best practices as set by experts in the occupation into which they are progressing. In this regard, higher education must be reviewed critically; especially the instructional practices as well as teaching methodologies that lead to the improvement of learners' vital abilities as explained by Mohsen, WahnZah and Mariah (2013). This agrees with the aspiration of technical vocational education and training (TVET), which is to give provident visionary to trainees in readiness to be absorbed by the world of work because it is an ability-orientated field whose main focus is inculcating technical skills and aptitudes to its recipients according to Ayonmike and Okeke (2016). Thus, the technical skills emphasis is the ultimate goal of training mechanical engineering in TVET institutions. The actual answer to enhancing productivity from vocational training lies in understanding the many decisions trainers take as they interact with students during the learning process as said by Lucas et al., (2012). Therefore, instructors in TVET institutions should apply relevant teaching methodologies so that the students can acquire hands-on experiences that meet the market demand for employability and entrepreneurship by the end of their training course.

The success of teaching and learning depends on didactics used in any field of study as well as the pedagogy i.e., the strategies or methods of instruction applied in the classes, laboratories, workshops or any place where learning takes place as explained by Harman and Bich (2010). It can therefore be inferred that the degree of knowledge retention depends on the pedagogy involved although not in an exclusive manner. This implies that the best way to improve the acquisition of technical skills is to upgrade the teaching methods. This is justified by teaching and learning a broad scope of all such actions and processes that are required by learners to develop cognitive and psychomotor skills (Faye, 2011).

Appropriate teaching methods for technical skills acquisition are underscored by the essence of equipping trainees with the specialized and expert capacity needed for any country to succeed both financially and economically (Ansah and Kissi, 2013). The utilization of inappropriate teaching and learning methods especially at technical institutions frequently brings about learners who do not have adequate hands-on skills, have low creativity, and cannot be employed easily (Udofia et al., 2012). This argumentation is echoed by Lumumba et al.,(2020) who reported that among other problems, the syllabus in many of the TVET colleges and institutions is theory-based. The emphasis in Kenya is placed on passing examinations and being awarded certificates or diplomas. In these colleges, teachers use traditional teaching methods where teachers mainly ask their learners to reproduce and memorize the curriculum content as they were taught in class. In most cases, the students recite the lessons when they are examined and this produces graduates with low levels of skills. In addition, Obwoge et al.,(2013) accentuate that compared to the developed countries, linkages and collaborations between TVET institutions and industries are still far below expectation. This situation has often left many technical graduates unemployed (Adam, 2011). Instructional methods should be carefully selected to cater for different categories of learners especially those who need hands-on skills and specific competencies in many exceptional contexts as explained by UNESCO and UNEVOC (2014).

TVET institutions should be conscious of the demands and expectations of the labour market. Globally, many governments have made changes toward improving the standards of engineering education by reviewing teaching methodologies of the wide range of subjects offered (Borrego et al., 2014). The aspect of student acquisition of learning experiences depends on the quality of instructional methods. Therefore, the best intervention to make is to apply systematic inquiry and intellectually challenging methods. The teachers need to work collaboratively by actively involving their learners while trying to assess their learners in class according to Angelo and Cross (1993). However, regional inequalities and discrepancies in the education sectors still prevent economic prosperity as explained by Krishnakumaryamma and Venkatasubramanian (2018). Besides, several studies in different countries have been conducted about teaching and learning in TVET institutions. Many studies however have shown that TVET institutions have shortcomings, especially in skill acquisition in most countries according to research conducted by Mulati et al., (2019).

Countries such as Singapore, Hong Kong, South Korea, and Taiwan have had fast-growing economies since the 1960s because they have put in place good policies for both university and polytechnic education. A lot of resources have been pumped to technical and vocational education and this has produced highly skilled manpower according to research done by Maame (2018). In China, Bai and Geng (2014) noted that learning institutions should diversify methods of instruction like project-based teaching and learning, case study teaching, situational teaching and computer-aided teaching (virtual and simulated teaching), to produce skilled learners. According to research done by the World Bank, it was shown that some of the middle-income countries found in East Asia became industrialized because over 50% of their high education students are registered in TVET programs. Some of these countries are China and Korea (Ohno, 2014). In Germany, there is a dual education system which integrates school-based learning with industry or work-based practice. Germany thus produces well-trained employees in large numbers because many young people go through vocational education and training programs instead of going to study at universities. Germany has more than 326 professional trades, it is a very a unique education system, among these trades there are; diamond cutters, aircraft mechanics and chimney sweeps. In Germany, young people prefer to follow their passion through vocational education and training rather than pursue higher learning, Niranjan, (2018). In the training of the workers, 80% of learning is done in industries while the remaining 20% is done in colleges (Mongkhonvanit, 2017). Training is tailored to meet the requirements of the employers therefore the German model, are action, practice and application-oriented models of instruction as eluded by UNDP (2010) and Niranjan (2018).

In Africa, owing to incessant challenges, the tradition in TVET is inclined towards obtaining hands-on skills that are required for the development of a skilled workforce (Maame, 2018). In South Africa, Arfo (2015) analysed comparatively TVET policies in selected African countries. The countries included Nigeria, Ghana and South Africa to look for similarities and differences in the system. From this analysis, it was clear that TVET policies execution was poor in all the countries under study. All the countries were not able to produce the relevant skills needed in the industry. It was evidently clear that in Ghana, for example, graduates from technical institutes did not have the requisite skills needed in the employment market. It is for this reason that many graduates from the institutes could not secure formal employment (Adam, 2011). Audu (2014) conducted a study in Nigeria and found out that work-based learning, field trips, project-based learning (PBL) as well as seminar and simulation methods of instruction enhanced the gaining of technical and employable skills by learners simultaneously. Nevertheless, these methodologies were infrequently applied in most of the teaching and learning institutions that offered TVET. The main reason for this was either due to insufficient funds and/or instructional facilities not being equipped to par.

Anindo et al., (2016), in their study, carried out in Nairobi County in Kenya it was revealed that TVET institutions did not have adequate and modern equipment that could compare with those found in the industries and many of the workshops were under-equipped. They further argued that training equipment influenced the uptake of hands-on skills. It was also established that instructors in these institutions applied lecturing, demonstrations, work-based teaching and learning and discussion methods because of a large number of students and inadequate training equipment. Other issues bedevilling

TVETs as identified in this study were; inadequately trained teaching staff and rigid exam-oriented curriculum. In conclusion, the learners who completed TVET courses were surprised when they eventually joined the job market.

Besides, the teaching and learning system in Kenya has been described as being inflexible and out-dated or non-compliant with the needs of the industry. Because of this, the training institutions release graduates who have irrelevant skills that do not march with those demanded by the industry according to research done by Ngure, (2013). A study by Udofia et al., (2012), showed a correlation between the instructors' quality, the instructional methods and teaching facilities on how employable skills are acquired by learners.

The Kenyan government is keen on ensuring that students acquire the right cognitive skills, views and hands-on skills to be employed or independent in self-employment (Government of Kenya, 2012). There's little empirical evidence on the effect of teaching methods as one of the factors that may affect the acquisition of technical skills amongst mechanical engineering students. Thus, this study was designed to investigate whether the methods of teaching have a significant influence on how students acquire technical skills amongst mechanical engineering students in the selected national polytechnics in the western Kenya region.

1.2 Statement of the Problem

The main reason for which TVET exists in a country is to give people the much-needed technical and professional skills necessary for social, economic and industrial growth, (Ansah and Kissi, 2013). There exists a correlation between teaching methods and learners' technical skill uptake (Udofia. et al., 2012). The real solutions to improving benefits from technical and vocational education depend on understanding the decisions teachers make as they interact with their students during learning the learning process (Lucas et al., 2012). The application of improper teaching and evaluation methods especially in practical subjects can produce learners who lack hands-on experience, inadequate innovation and creativity as well as a redundant workforce that cannot find employment as researched by Udofia et al., (2012) and Lumumba et al., (2020). Further, the problem is exacerbated by poor linkages and collaboration between TVET institutions and industries resulting in gaps between training and labour market needs in Kenya (Obwoge et al., 2013). TVET trainers should therefore use appropriate methods of instruction to maximize student acquisition of practical skills that are in tandem with the demands of the human resource market for sustainable development (UNESCO and UNEVOC, 2014).

In Kenya, little empirical evidence on the effect of instructional/teaching methods on the acquisition of technical competencies amongst mechanical engineering trainees in Kenya exists. The present study is an effort toward understanding the effect of teaching methods on the acquisition of technical skills by mechanical engineering trainees in three national polytechnics in the Western Kenya Region.

1.3 Purpose of the study

Currently, no research has focused on teaching methods used to train mechanical engineering technicians in technical training institutes and TVET institutions in Kenya. However, from a general perspective, some research by Ngure (2013) and Ferej et al., (2012) has indicated that there are potential problems with teaching methodologies currently in use. As a result, there is a need for an assessment of the teaching methods used in technical training and TVET institutions in Kenya to help unearth associated problems to help to improve or suggest alternative methods that can help fill in identified gaps. Therefore, an evaluation of the effect of different teaching methods on the acquisition of technical skills amongst mechanical engineering trainees in national polytechnics in the western Kenya region was conducted.

1.4 Objectives of the study

The main objective of this study was to assess the effect of different teaching methods on the acquisition of technical skills by mechanical engineering students in national polytechnics situated in the western Kenya region.

The specific objectives of this study were, to;

i. Assess the effect of work-based learning on the acquisition of technical skills amongst mechanical engineering students in national polytechnics in the western Kenya region.
ii. Examine the effect of tutorial teaching on the acquisition of technical skills amongst mechanical engineering students in national polytechnics in the western Kenya region.

iii. Evaluate the effect of problem-based learning methods on the acquisition of technical skills amongst mechanical engineering students in national polytechnics in the western Kenya region.

iv. Assess the effect of project-based learning on the acquisition of technical skills amongst mechanical engineering students in national polytechnics in the western Kenya region.

v. Evaluate the effect of workshop training on the acquisition of technical skills amongst mechanical engineering students in national polytechnics in the western Kenya region

vi. Evaluate the combined effect of work-based, tutorials, problem-based learning, project-based and workshop training in national polytechnics in the western Kenya region.

1.5 Research questions

This research aimed to find answers to the following study questions:

i. What is the perception of work-based learning on the acquisition of technical skills amongst mechanical engineering students in national polytechnics in the western Kenya region?

ii. What is the perception of tutorials on the acquisition of technical skills amongst mechanical engineering students in national polytechnics in the western Kenya region?

iii. What is the perception of problem-based learning on the acquisition of technical skills amongst mechanical engineering students at national polytechnics in the western Kenya region?

iv. What is the perception of project-based learning on the acquisition of technical skills amongst mechanical engineering students in national polytechnics in the western Kenya region?

v. Does workshop training affect the acquisition of technical skills amongst mechanical engineering students in national polytechnics in the western Kenya region?

vi. What is the combined effect of work-based, tutorials, problem-based learning, project-based and workshop training in national polytechnics in the western Kenya region?

1.6 Justification of the study

According to Obwoge et al., (2013), linkages between TVET training institutions and respective industries are so low in Kenya compared to industrialized countries. They further argued that there exists a very large gap between training and the demands of the skills market in Kenya. Teachers use traditional teaching methods and recent qualifiers or graduates from the TVET institutions of learning have low competencies in practical skills among other problems, Lumumba, Kisilu, and Dimo, (2020). Complaints also abound on teaching staff attitudes, especially poor communication and unwillingness to change thus compromising the acquisition of technical skills. In addition, trainers' pedagogic approaches, strategies and practices are a cornerstone for the effective acquisition of technical skills. Nonetheless, the problems facing this area are caused by poor preparation by TVET instructors while executing their duties (Blom, 2016). Therefore, an evaluation of the current teaching methods, including trainer and trainee perceptions on gaining knowledge and technical expertise by mechanical engineering students in national polytechnics in the western Kenya region was conducted to identify gaps and suggest solutions for effective teaching and acquisition of technical skills that meet the human resource demands of the Kenyan market.

1.7 Limitations of the study

The study area was purposefully selected and restricted to three national polytechnics in the Western Kenya region. Teaching methods have an impact on the acquisition of technical skills and these may differ from one institution to another. An evaluation of all instructional methods in all technical training institutes and other polytechnics in other regions of the country will be necessary for a more holistic picture and approach to effective teaching and acquisition of technical skills.

Among the selected national polytechnics there could be several intervening variables which may have resulted in data bias. Uptake could have also been influenced by the administration, infrastructure level, ICT use and integration, student and teacher population, motivation of teachers and so on. Moderators used in the assessment of the correlation between teaching methods and acquisition of technical skills can introduce biases in the study.

The use of any single method e.g., census could perhaps have given different results since everybody would have been asked their views and consequently, the findings would be different. This study used questionnaires only could have also compromised the reliability of the findings. The determination of the effect of teaching methods on skills uptake was limited to self-evaluation by teachers and students’ ratings.

1.8 Delimitations of the study

The study concentrated on student-centred teaching methods; work-based teaching, tutorials, problem-based teaching, project-based teaching as well as workshop training and how they affect technical skills acquisition amongst students in national polytechnics in the western region of Kenya. The research focused only on students and teachers in Government sponsored national polytechnics in the Western Kenya region. The students sampled were those attending regular studies. This research was carried out between December 2015 and June 2016.

1.9 Theoretical framework

The study considered the relevant theories that the study variables were hinged on. The constructivism and cognitive learning theories were adopted in trying to understand the correlation between instructional methods and the acquisition of technical skills.

1.9.1 Constructivism theory

Dewey (1929), Bruner (1961), Vygotsky (1962), Piaget (1980), and Sarita (2017) are the proponents of the constructivism theory which says that knowledge exists in the brain of a human being and it doesn't compare with any real-world reality. This theory explains that learners can develop knowledge through real-world experiences or that their representations are developed from pre-existing information. This theory explains how people acquire knowledge and learn. In constructivism theory, the learner is considered as being active in the process of obtaining knowledge. Through experience, learners make their understanding and representations as they reflect on pre-existing knowledge according to Bada and Olusegun (2015).

Constructivist methods of teaching include; collaborative thinking, project-based learning, and peer teaching. From the constructivist point of view, this kind of teaching and learning emphasizes social interaction through learners' interaction while working in groups, discussions and enhanced communication skills. This kind of learning encourages systematic information construction rather than spreading information. Learning takes place through new experiences and thoughts linked to the past. In light of constructivism, learning ought to be organized around ideas that encourage the improvement of information and abilities instead of information diffusion (Dogara et al., 2020).

Constructivists believe that learning is a repeated social interaction since its foundation is inculcated within a social context. Both the learners together with their instructors build knowledge based on previous ideas taught (Sarita, 2017). The pertinent point in constructivism is that knowledge is constructed rather than passively received. Learning is an active process and teachers need to use appropriate teaching techniques or methods to help learners to share skills with their trainers by doing so the process of acquiring skills is enhanced. It should be understood therefore that the main objective of teaching is to give learning experiences that promote the way knowledge is constructed and this is mainly by learners being active during the learning process (Ebrahimi, 2015). Constructivism gives learners a chance to own what they have acquired in terms of skills and knowledge as learning takes place from questioning themselves and their explorations. In most cases, learners contribute to constructing their judgments too (Sarita, 2017) and Jonassen (Jonassen, 1992), said that a good teaching method should provide an appropriate learning space for effective skills acquisition. However, this method of learning has been criticised for shortcomings like different learners may view the challenges and experiences in a very diverse manner. Further, still, this methodology may not be effective since significant concepts in the syllabus are not developed by learners (Alanazi, 2016)

1.9.2 Cognitive learning theory

Cognitive learning theory (CLT) was improved by Albert Bandura in 1986 as an expansion of his social learning theory (McCullough Chavis, 2011) . The CLT explains that when a person studies a model performing a behaviour and the results of that behaviour, they recall the chronological occurrences and use this information to develop successive behaviours. The CLT gives a way of learning, predicting and diverting human character according to Carrington et al., (2010). With respect to character, other researchers like Betz (2007) concurred with Bandura's preliminary assumptions of CLT, that behaviour is pointed or directed towards specific objectives. Behaviour is eventually self-controlled. Mental processes that are involved in learning are important; studies also show that desirable stimulus and punishment will have indirect effects on learning as well as on behaviour (Nabavi, 2012).

Schunk (2012), says that cognitive learning theorists insist on obtaining skills and knowledge, improvement of mental structures, and redefining information and ideologies or beliefs. Ausubel (2012) also indicates that learning is an internal mental aspect that is derived from people. Cognitivists believe that learning is better when one is fully involved.

Trainers should arrange their instructional materials in a simplified manner that can be easily comprehended by learners' minds. The trainers are required to use various methods and techniques, and subjects and their content need to be broken down into smaller parts. The sub-topics should be presented by teachers in a way that they supplement one another. Learners should have confidence that they can do an assignment or task especially when they need to produce an intended result. On the other hand, trainers can also achieve their objectives by giving learners positive reinforcement, watching successful colleagues, and also being actively involved. (Slavin, 2019). From research, the theory has proved to be difficult as it is not easily comprehended and applied in the learning process. Even further, scientists at present have not discovered a correlation or association between self-viability and observational learning within the social-cognitive perspective. This hypothesis is wide to the extent that not the entirety of its parts is completely perceived and incorporated into a solitary clarification of learning (Schunk and Zimmerman, 2012).

1.10 Conceptual framework

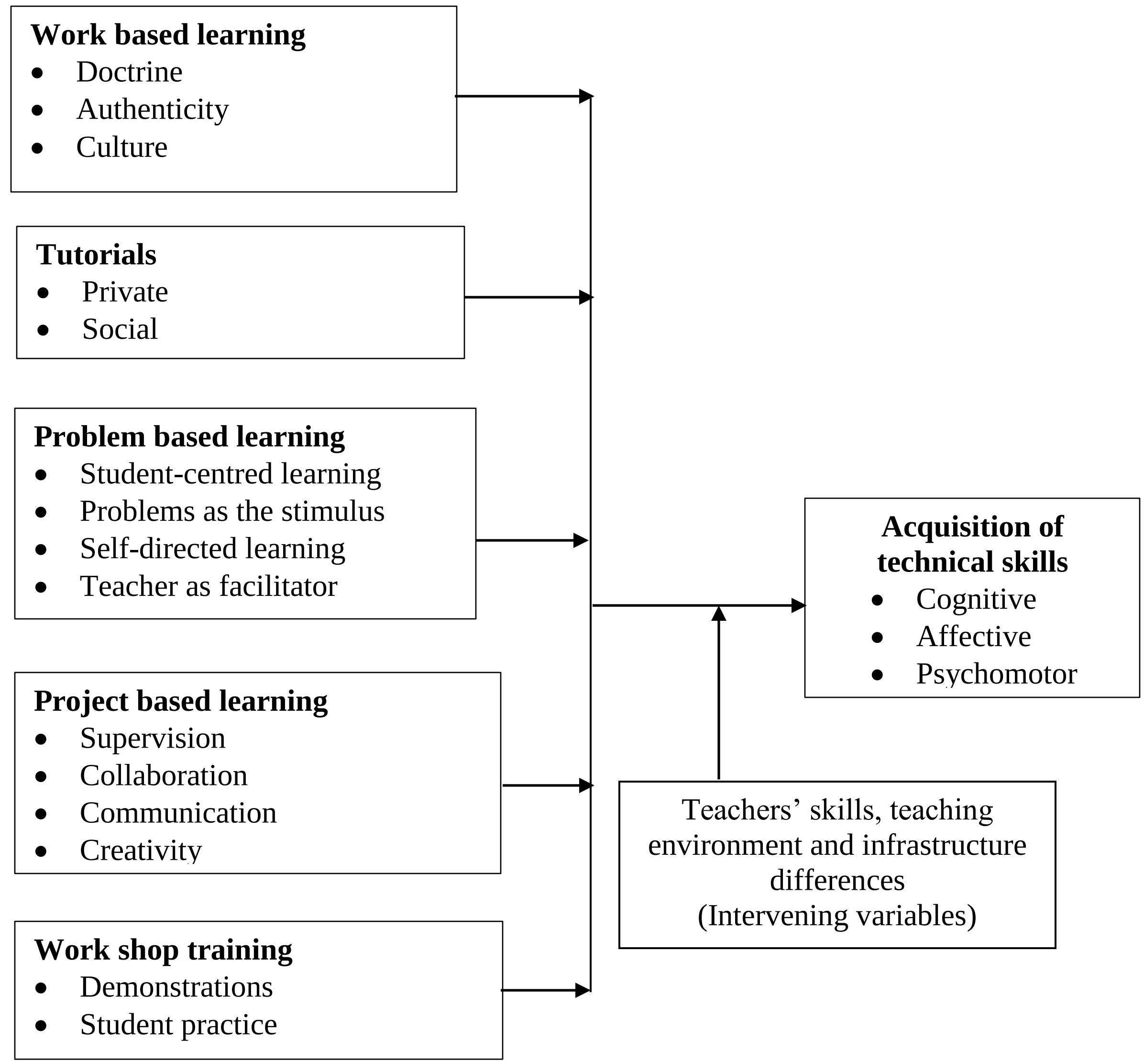
This conceptual framework was developed before the commencement of the research. This research conceptualized the relationship between the effects of teaching methodologies on the acquisition of technical skills by trainees of mechanical engineering in national polytechnics. The research concentrated on the methodology of teaching i.e., work-based learning (WBL), tutorials, problem-based learning (PBL), project-based learning and workshop training. WBL is a type of learning which supports the personality and professionalism of learners who are already working and the activities they do at their workplaces enable them to develop their skills (Holden et al., 2010).

Tutorials or the review of lessons is viewed as a process where an experienced trainer or 'adult' assists another person who is less experienced (Cleveland-Innes et al., 2014). Tutorials as a teaching method affect the acquisition of skills and measurement of learning outcomes in terms of interactivity which are classified as private and social interactivity as explained by Hrastinski *et al*, (2019).

PBL is a teaching method whereby complicated real-world challenges are used as motivation to enhance knowledge acquisition. The main features of problem-based learning are; that it is a student-centred method, students will normally study in relatively small groups, the teachers are facilitators and problems are the main stimulus for learning since the problems identified reflect the real-world situations and the acquisition of skills is self-directed (Bhina, 2015). Bell (2010), defined problem-based learning (PBL) as "a student-driven, teacher-facilitated approach to learning". The scope of PBL is composed of collaboration, supervision, creativity and communication as components of PBL (Anabela et al., 2017).

The workshop training method was studied in terms of demonstrations and students' practice adopted format (Browne, 1952), Masek (2012). Knowledge acquisition is related to information attainment, obtaining concepts, principles, and procedures. The acquisition of technical skills should be measured in terms of three branches of learning activities cognitive, affective and psychomotor according to Hyland (2017) and Ramalingam et al., (2014).

This research conceptualized the acquisition of skills mainly through the teaching methods that influence the three faculties; cognitive skills (intellectual or mental skills), affective skills (attitudes and values) and psychomotor skills **(**manipulative or physical or movement skills).



Independent variables | **Dependent variables**

(Teaching Methods) | (Acquisition of Technical Skills)

Source: (Author 2020)

Fig 1.1 Conceptual framework

1.11 Operational definition of terms

Project-based learning (PBL): This is an activity-based learning method where the students get skills by engagement in the real world and personal projects. Learners usually prove their knowledge by making a product or making a presentation of a real project to an audience.

Teaching methods: These are pedagogical or management strategies that promote a learning outcome. These are usually done by learners and teachers.

Technical skills: These are capabilities and expertise needed in doing physical or digital tasks. They are usually practical skills required specifically to accomplish a specific task or job.

Acquisition of technical skills: Refers to competency or expertise attainment in terms of concepts, principles, and procedures in undertaking a physical or digital task/s.

Work-based learning (WBL). It is a type of learning where learners do real work by producing goods and services either by receiving payment or by voluntary work. This kind of learning gives the learners a chance to receive knowledge and skills that they will not easily get in a classroom setup.

Tutorial teaching method*:* It is a teaching method usually a one-on-one session between a teacher and a student or a teaching session given to a small number of learners.

Problem-based learning (PBL): This is a teaching method involving learning difficult real-world challenges or problems as a motivator for students to learn ideas together with the teacher as opposed to direct teacher instruction or conventional learning.

Workshop teaching: a type of teaching that enables learners to learn how to handle machines produce items and tools as well as safety.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter starts by focusing on some TVET systems across the world that have different structures, and general teaching methods and focuses on findings from research on how teaching is done and general teaching methods globally. Various types of research are looked into taking into account the perception of the authors. Explanations of how, why and when the methods of instruction are used have been looked into with the view of bringing out a broad picture of what an effective teaching method encompasses. Further analyses of the methods of instruction proposed and used in engineering education have been included to see their strengths and weaknesses. Finally, specific literature on TVET has also been reviewed to give a picture of how the specific teaching methods of instruction are applied in Africa and Kenya.

2.2 Empirical review

The empirical review covered the conceptualized relationship of variables under study which includes the notion of instructors and learners towards teaching methods as the independent variable and acquisition of technical skills in mechanical engineering as the dependent variable. This research zeroed in mainly on the perceptions of teaching methods by various authors on work-based learning method (WBL), tutorials teaching methods, problem-solving method, project-based learning and workshop training.

2.2.1 Work-based learning and teaching method and acquisition of technical skills

According to Huq and Gilbert (2013), work-based learning (WBL) is an academic approach that gives students actual-working experiences through the application of academic and technical skills and this broadens their chances of being employed.

On the other hand, Cahill (2016) discusses WBL as activities that are attainable in the work place are aimed at promoting knowledge and skills for learners to progress in a certain career or field of specialization. In America, work experience is required by low experienced workers and jobseekers, young people of sixteen years to twenty-four years and this is only possible if the learners are attached to the workplace. This has pushed the leaders and educators to WBL so that these vulnerable groups can be absorbed in the employment market.

Eames and Coll (2010), argue that workplace learning is increasingly applied to youths and adults in job-related training as well as educational programs. Tertiary education providers should incorporate work-based learning as part of their response to the employers' needs. Work-based learning is increasingly becoming a pertinent component of job-related education and it may be in form of apprenticeships, internships, school-supervised education or cooperative education.

According to Hamilton and Hamilton (1997), there are eight main areas involving WBL which were summarized into three groups: the first involves one-time visits to workstations or multiple visits, secondly, gaining work experience through working as an intern without being paid and finally employment of young or youthful people at subsidized rates.

Many types of work-based learning are geared towards making education applicable to the job requirements and promoting smooth adjustment from school to work. Teachers regularly see WBL as slowly coming into professional recognition, exploration, guidance, and training activities beginning with guest speakers, informational interviews, and visiting workplaces and student internships as well as apprenticeships (Capel, Leask and Younie, 2019). In addition, work-based learning is intentional, experiential and takes place in areas where goods or services are produced as explained by Mumford (2016).

The design of the quality of the WBL activities intended for learners should meet the demands of the education and industry by taking into consideration contextual and experiential strategies for learning. This is possible if methods of teaching are not similar to classroom-based methodologies (Kukulska-Hulme, 2012). Workforce developers usually interpret WBL as practical experiences at the workplace that are extremely important in providing for career advancement. These hands-on experiences allow the trainees a leeway to employment in form of on-the-job learning, apprenticeships, internships and transitional jobs (Riemer, 2012).

The European training foundation (2013) sees work-based learning as having two dimensions i.e., learning in a work context that is guided by employers' requirements and also learning by practising. WBL allows the learners to gain general education by producing a broad range of high-quality relevant skills. Studies conducted in UK, Morocco and Germany indicated that it made economic sense. However, this method was found to have issues with; a lack of legal frameworks, poor perceptions from employers and a clear lack of involvement of stakeholders and social partners. WBL in Germany's dual system is however successful because of the strong stakeholder participation. WBL-related guidelines and practices in vocational education and training (VET). However, these assessments were in a non-Kenyan context limiting the generalization of the policies to the Kenyan context.

Haruna, Kamin and Buntat (2019) investigated the level of applicability of WBL in the TVET system of Nigeria. The research respondents constituted one hundred and fifty TVET trainers at tertiary colleges. A mixed research methodology was used mainly because of its suitability for giving in-depth information through discussions. This study found that there was a low level of WBL awareness in Nigeria. This study only focused on the awareness level of work-based learning but not the perception of technical skills acquisition providing a gap for the current study.

Amadi, (2013) evaluated WBL experiences of teacher education in Nigeria’s technical and vocational teacher education and training programs. From seven technical colleges of education, a sample of two hundred TVET trainers was selected. It was found that the student industrial work experience scheme (SIWES) ranked best while other teaching methodologies such as cooperative work experience program, youth apprenticeship program, job shadowing, school-based enterprises, clinical work experience, and internships, among others, were almost left. From this study, the reasons for these problems were; bad policies, curriculum deficiencies and inexperienced administrators of TVET programs. This study recommended that there should be government-industry linkages, restructuring of the curriculum and frequent refresher courses for TVET instructors. However, the study did not focus on mechanical engineering it focused on teacher training education. The study also used descriptive statistics and not inferential statistics thus could not conclude the extent of the effect of work-based learning on skill acquisition in mechanical engineering.

Adam (2011) explored and described challenges involving practical skills acquisition facing graduates from technical colleges located in the upper east region of Ghana through a descriptive survey. Responses from this study were analysed using descriptive statistics. It was revealed that there was an inadequate supply of instructional materials, big numbers of learners in classes, inadequate training facilities, and weak linkages with local industries for both instructors and trainees were the main cause of ineffective training of learners. It was also revealed that emphasis was put on students passing their final examinations and this eventually created a situation that explains the inadequacy of skills needed for the job market by the graduates. The study didn't focus on work-based learning but indicated that there were challenges to knowledge acquisition in the Ghanaian context.

Ondieki et al., (2018) conducted a study about the perceptions of the effectiveness of industrial-based learning programmes of former students of the University of Nairobi, Kenya. The study focused on students who had graduated between 2007 to 2011 with degrees in Bachelor of Science in electrical and electronic engineering. The former students indicated that industry-based learning was inadequate because of the failure of university lecturers to adequately supervise students and also the University's failure to find attachments for its learners. However, the employers considered industry-based learning as being very important because it improved the productivity of the employees. The study also found that attachments for undergraduate students in the industry were very important in giving them important skills which will allow them to be employable after university education. The study also recommended that industry-based learning should be strengthened. However, this was a case study and therefore it limits the generalization of the findings to TVET institutions.

2.2.2 Tutorials and acquisition of technical skills

A tutorial is an individualized method of teaching and is interactive between the learner and instructor or may comprise three to four students and an instructor. The method is characterized by discussions and presentations in small groups based on abilities (Cook-Sather et al., 2014). Harisim (2017), emphasized that students should be chronologically taught in a manner that content is gradually moved from concrete to abstract and vice versa. To achieve this, an instructor is required within the teaching environment to have an interactive and guided class. Johnson et al., (2019) in a study that involved lecturers of mathematics, it was revealed that lecturers presented a lot of questions to their learners and never allowed them to interact with themselves. Based on this argument, tutorials could allow students to engage more critically with the concepts of the course as well as the discipline knowledge.

Cheng., Joselina., Swanson and Zane (2011) conducted a study on web-based tutorials and how they impacted the skills of accounting students. This was conducted in 2010 at Southwest University. The study targeted students enrolled in accounting classes and the participants were randomly selected and subjected to control and treatment groups. While one group (control) received ordinary lectures, the other group (treatment group) was subjected to multimedia teaching and learning modules. In addition to the multimedia-based learning module, the treatment group had electronic tutorials. Both the groups were given pre-tests and post-tests and the results showed that the groups that received e-tutorials had one letter grade higher than the control one. This showed that the application of improved technology and strategic pedagogies enhanced the acquisition of skills. However, the study was not conducted in the Kenyan context and also focused on business students.

Neuss (2014) during software training compared two groups of learners. They were divided into control and treatment groups from a sample of fifty-five participants randomly selected from middle schools. In this study, the experimental group received training instructions from regular videos and regular reviews were also done whereas the control group only received regular video instructions. The experimental group thus performed better during the instruction period as well as the post-test scores. The study was not conducted among mechanical engineering students in TVET institutions in the Kenyan context thus limiting the generalization of the findings.

Cousins et al., (2012) conducted a study at the University of Aberdeen by assessing the effect of tutorials on skills development among first-year biological sciences students. This investigation used evaluation sheets, learner's diaries and focused group discussions. This study investigated whether the students had learnt transferable and generic skills and whether they had attained a good level of curiosity in their studies. The study found out that the course had assisted the learners in acquiring important skills as well as increased their confidence. However, the study focused on the university students doing biological sciences from Aberdeen and not mechanical engineering students limiting its generalization.

Madden and Slavin (2017), did a study in inner-city Baltimore involving struggling readers. This was a computer-aided teaching strategy known as tutoring with alphine (TWA). The results showed that using technology was more cost-effective when offering tutorials to many students than doing it to individual students. However, the study didn't focus on effectiveness in terms of skill acquisition but on cost. Besides, the study was not conducted in TVET institutions; especially on mechanical engineering students in Kenya therefore this provided a gap for the current study.

2.2.3 Problem-based learning and acquisition of technical skills

Problem-based learning (PBL) method as a teaching method makes learners develop the urge to learn and motivates them to develop skills of critical thinking as well as problem-solving ideas that can help them in life as alluded to by Kolmos and de Graaff (2014). In PBL, students learn in groups by solving problems that more often have several answers or solutions. This makes learning more interesting as it incorporates theory and practice. A defined problem is thus solved by the application of knowledge and skills (Savery, 2006). English and Kitsantas (2013), argue that for learners to acquire skills, they need to be more responsible. The learning process should be self-regulatory in terms of motivation, objectives, self-reflection as well as the monitoring process. The researchers concluded that only teachers who have the knowledge and training on PBL can support learners. According to Hattie (2012), teachers act as guides in the process of learning in PBL; the teacher supports and guides the learners in this learning process, the teacher just gives time limits and designs a framework of expectations. Learners on the other hand are given real-life problems in particular contexts that help them to develop critical thinking abilities and this improves their reasoning. However, the writer warns that this method of teaching is suitable for mature students and should be designed in such a manner that it enables students to know how to solve problems and develop critical thinking skills. Generally, PBL requires the use of many resources, formulation of ideas and working together in groups. Hatie, (2012) also argues that PBL and inquiry-based learning has a size effect of 0.31 which is a very low effect on the overall teaching process. However, this argument was about young learners. The writer emphasizes that this method of instruction is very useful when the learning strategy intends to solve real-world problems in very realistic situations.

Baharom and Palaniandy (2013), researched pre-university learners. They received written feedback after a three-week PBL teaching session. From the analysis of these responses, the PBL had strong support that it helped the learners acquire knowledge and generic skills. The learners indicated that they were able to acquire problem-solving skills, analytical thinking, improved communication, enhanced team spirit, life-time skills among others. The research further recommended that PBL as a teaching method is suitable in the medical field. However, the study was not conducted with engineering students at TVET institutions and this provided a gap in this study.

Ibrahim et al., (2018), conducted a study on the efficiency of PBL in acquiring knowledge and soft skills at a medical school. Questionnaires were administered after the validation of the items. The items in the questionnaire are intended to investigate the perceptions and attitudes of the learners towards the acquisition of knowledge as well as soft skills. Independent and paired t-tests were done and these were used to compare means and standardized deviations (SD). A value of $p \leq 0.05$ was deemed statistically significant. Many students had a positive perception of all elements under investigation thus confirming that PBL was important to the learners. However, there was no significant difference in the mean value and standard deviation in the acquisition of knowledge and soft skills in the assessment of students in their second year and third year respectively. After repeated module application of PBL, it was found to be effective. However, the study didn’t consider the perception of teachers but only students and the study was not conducted in the TVET institutions amongst mechanical engineering students in the Kenyan context.

Al-Drees et al., (2015) evaluated the learners’ perceptions of problem-based learning (PBL) sessions in a system-based hybrid program of studies. Self-administered questionnaires were used in the college of medicine, King Saud University, Saudi Arabia. The majority of the learners said that the PBL learning periods were useful for them as they assisted them to get elementary science concepts. The students indicated that this method of teaching encouraged self-directed learning and collaboration among the students and improved the students' capacity to make better decisions. Some students indicated that they did not like this method due to a lack of induction training before the commencement of PBL sessions. 25.1% of the responses from students were positive in the sense that their teachers were ably informed about this method of instruction. The study, however, revealed that most students used lecture notes, the internet, and textbooks as learning resources. The limitation to this approach of teaching was that both the students and teachers needed to be trained before adopting it. This study was limited in its application given the fact that it was conducted on medical students.

Orhan and Ruhan (2007) determined the effects of problem-based active learning on seventh-grade science education students' academic achievement and concept learning. Qualitative and quantitative statistical approaches were used in this study. The qualitative analysis involved document analysis while quantitative data was obtained from pre-testing and post-testing analysis of a treatment group and control group test model. This study utilized three instruments namely; open-ended questions administered an achievement test, and an attitude scale. The treatment group was subjected to PBL but the control group received traditional teaching methods. Analysed data collected showed that the implementation of the PBL learning model had a positive influence on the students' academic success as well as their attitude improvement in science. This study was conducted on science education students and not mechanical engineering students in the Kenyan context limiting the generalization of the findings.

Athur (2018) described PBL as a learner-friendly methodology where learners work collaboratively; learners are given real-life problems and can think critically. The research was done to determine how many African engineering students could successfully perform the disassembly into parts and then re-assemble the parts of two-stroke motor engines back to working condition. This was longitudinal research that used descriptive statistics. From this study, 85.5% were able to successfully do the disassembly and assembly procedure in the engineering module. From this study, it is clear that these learners had practical or hands-on skills in respect of engineering concepts, equipment manipulation and machinery operation skills. The study adopted only descriptive statistics which could not give the actual magnitude of the effect of the independent variables on dependent variables. Thus, inferences could not be effectively made on the effect of the problem-based learning method on the acquisition of technical skills.

Masek, (2012), conducted an experimental study which used a pre-test and post-tests analysis on electrical undergraduate students in the Malaysian polytechnic. The study was on how knowledge acquisition specifically to procedures principles and concepts within the learners was influenced by PBL in comparison with conventional methods. Two groups were formed; a control and a treatment group. The treatment group was subjected to a 10-week PBL procedure while the control group received the conventional teaching. Data collected was analysed by MANCOVA software. From the findings, students' knowledge acquisition in the treatment group was significantly higher than that of the control group. On the other hand, students' intrinsic motivation, in the treatment group was more significant compared to the control group. Finally, the students' critical thinking ability did not show any significant difference between the treatment and the control group (TLA group). From these findings, it was concluded that PBL enhanced students' knowledge acquisition, but did not improve the students' critical thinking ability compared to the traditional approaches. However, the sample size in this study was small and this limits the generalization to larger populations besides the contextual differences between Malaysia and Kenya.

Nur et al., (2017) studied the PBL teaching and learning approach in civil engineering education particularly, highway engineering. Self-administered questionnaires were used on several groups of students and one of them was chosen as a project manager of each of the groups. Apart from the group manager the rest of the students acted as model developers or designers. The groups under this study were assigned real world-problems so that they could find solutions to these problems through discussions and finally create a scale model based on their resolutions. The students' and teachers' perceptions of the effectiveness of PBL in engineering were measured through self-administered questionnaires. This study found out that the PBL method had positive benefits on the learners which included technical skills as well as soft skills improvement. It was therefore concluded that PBL had pedagogical implications for engineering education. However, the study was not conducted in the Kenyan TVET context limiting the generalization of the findings.

Elsie et al., (2010) conducted a study at Makerere University in Uganda within the College of Health Sciences. From this study, it was clear that the lecture-based method of teaching had been in use since 1924. However, PBL was adopted after curriculum change for many undergraduate programs including radiography. The attitudes and perceptions of students and teachers about problem-based learning were studied in a cross-sectional descriptive study. This research used self-administered questionnaires and focus group discussions among the radiography students and the department. It was found that all students including 80% of trainers recommended PBL as a very good instructional method. All the students and teachers said that the PBL method was important for the acquisition of main generic skills such as problem-solving, teamwork and self-directed learning. This method lacked adequate learning resources, as well as student assessment in PBL, was noted as the major challenge. However, based on the study design it is limited in terms of generalization to the TVET institutions.

Podges et al., (2014), conducted research at Walter Sisulu University of technology (WSU) in South Africa to find out how PBL as a teaching method affected year one students in an analogue electronics course. The Problem-based learning method of teaching was compared to the lecturing method. There was a more positive attitude change among the student that used PBL compared to those who used the lecture method. There was an experimental and control group. Attitude, amount of reflection and learning outcome were measured. This study showed a strong correlation between the learners' skill acquisition for those who used the PBL method of learning. The research also indicated that the learners who used the PBL method could do research, acquired more skills and was more confident. They had more positive attributes and were more reflective in thinking. They also had more practical skills compared to the control group, however; the researchers concluded that there was no significant improvement in the learning outcome. This research concluded that PBL must be structured in such a way that it uses real-life problems and that industry should also be incorporated for it to be more useful. The research also found out that PBL was time-consuming and it was not easy to make small groups to tackle problems.

2.2.4 Project-based learning and acquisition of technical skills

The world has become more complicated in terms of what it demands in terms of careers. Because of these demands, there needs to be a change of teaching methods from conventional teaching methods to more innovative and student-centred learning methods. Thus, for those learning institutions willing to change, project-based learning will present such an opportunity. Project-based learning is viewed as a student-centred teaching method because it encourages students to ask questions, the students learn together in environments where they can talk to each other. Learners and instructors can also interact with each other. The main ideas and practices that this method of teaching emphasizes are setting a culture, designing and planning, inclusivity, management of teacher-student activities, assessment of learners' progress, scaffolding student learning as well as engagement of learners in activities according to Suzie and John (2018).

Bean, 2011 defined project-based learning as an instructional methodology that allows learners to get information (skills and knowledge) by working for an extended long period to study and come up with an authentic, involving and complex problem, challenge or question. According to Edutopia (2016), in Project-based learning, students work in groups and this encourages them to socialize, cooperate and communicate with each other during the learning sessions. The learners learn from real-life problems and the teacher is seen as a coach who guides the learning process. The student is actively involved through active manipulation of real-world problems. Bell, (2010), defined project-based learning as “a student-driven, teacher-facilitated approach to learning”. This method makes the learners active and allows the learners themselves to develop high-order thinking skills. Project-based learning is practical education since this type of teaching and learning approach emphasizes creativity, problem-solving, and learners’ interactions and involves learners working together in groups. By working together, the learners can discover new knowledge, develop organizational skills, discuss problems and find solutions amicably and become responsible. The learners are also able to decide how to present solutions to specific problems in a scientific manner themselves according to Indrawan et al., (2020). Learners can find solutions to the real-world issue by doing projects. Further, still the learners monitor the projects. From a general point of view, project-based learning usually tries to solve real-world issues (Larmer, 2014). The key characteristic of project-based learning is that it pays attention to learning by being innovative, discovering and also by performing specific tasks as explained by Blumenfeld et al., (1991).

Mioduser and Nadav (2018) conducted a study on how high achievers acquire technical skills as well as technical knowledge through project-based learning methods. The main goal of this study was to look at the procedure of knowledge construction by talented or gifted learners in high school. The study also looked at how the learners find answers to technical problems. This study showed a significant improvement in formal knowledge as calculated by standardized matriculation examinations; an increase in the level of technology, and enhanced resources for the projects; a high level of design skills studied and a favourable change of attitude towards technological studies. However, this study was not conducted amongst the TVET institutions in the Kenyan context.

Mohsen et al., (2013) did a study at Arak university in Iran about the outcome of PBL on students' self-motivated learning skills in an organisational-based education course that was offered Education Technology department. A sample comprising seventy-eight from the department of technology education area was selected. Two groups were created namely; the experimental group (Project-based learning method group) and the control group (conventional method of teaching). A self-directed learning readiness scale (SDLRS) was applied thrice in pre-test, first and second post-tests respectively. Project-based learning was applied to the experimental group and conventional methods of instruction were applied to the control group. Analysis of variance (ANOVA) tests indicated that learners taught by the project-based learning method did significantly better than the control group. However, the study was not conducted with mechanical engineering students and in the Kenyan context limiting its generalization. Besides the sample size was also low.

Anabela et al., (2017) researched the effects of project-based learning on the development of social skills in first-year industrial engineering students. Among the skills gained by this method of instruction was the ability to be in charge of projects and make an effective working force within multidisciplinary teams, workers who can be able to solve conflicts and have effective oral and written communication skills. Such workers can fit in different workplaces because they are responsible, can assess co-workers responsibly and have a positive attitude. However, the study focused on the acquisition of social skills rather than technical skills. The study was conducted in a non-Kenyan context and this limited its generalization.

Bin (2017), found out that the problem-based learning method impacted positively TVET learners, especially in their ability in acquiring technical capacities as well as social competencies. During the study, the project-based learning method of instruction allowed the learners to work in groups. There was an improved interaction process and there was positive feedback from the learners to the facilitator. During the project-based learning sessions, the learners were verbally more active. The learners were also able to convert theoretical experience into practice by the use of simulators. He however noted that the students had time limitations and overloading in terms of the number of assignments given during their studies.

Chemborisova et al., (2019) did a study on project-based learning as a means of developing and acquiring entrepreneurial skills by learners. This study applied questionnaires with sixteen items mainly focusing the technical skills, management, entrepreneurship and personality issues. The questionnaire used a three-point Likert Scale for the student response scale. A sample of one hundred and forty students was picked from two universities. The study indicated that PBL had 12% greater than the control group. Thirteen out of sixteen skills tested showed an increase of 8% ± 4%. Conclusively from this study, project-based learning helped economics students to be able to assess risks and make well-informed decisions about their projects. From this study, it is clear that project-based learning can influence the quality of basic entrepreneurial skills development in students. However, the study did not focus on engineering students in the Kenyan context and therefore it limited the generalization of this finding.

Mills (2002), investigated the effectiveness of project-based learning using third-year undergraduate students in South Australia (civil engineering department). The study found out that the predominant pedagogy was “chalk and talk”, or the lecture method even though previous research had indicated that the method was ineffective. Emphases were still placed on examinations as opposed to project designs which came late in finalist students. The study also analysed the perception of the relevance of project-based learning to the real world of civil engineering. This study used questionnaires, case studies, student journals, electronic mail as well as interviews. From this study, the learners agreed that they had developed generic skills and had developed in-depth knowledge beyond what the curriculum intended. From the students’ perceptions and comments, it was clear that project-based learning enabled students to do design projects better that the usual practice where the learners only crammed the content to pass written examinations and then forget this content soon after.

2.2.5 Workshop training methods and acquisition of technical skills

Maheshwari (2012) defined a workshop as a group of people comprising ten to twenty-five people who have a common interest or objective. These people will normally jointly congregate to do studies and solve issues through discussion and practice. At the workshops, the participants do a hands-on exercise to produce something.

In the context of engineering workshops, Gospel and Okayama (2010) explain workshops as, places that give elementary training in machining, as well as fittings and they, serve to supplement other training areas received by learners or apprentices within the industry.

Workshop training gives learners hands-on training programs and exposure to the latest technologies and them to acquire skills by building projects hands-on (Vasanth, 2019).

In cases where curriculum-based training is not developed well, workshops are a better alternative as they enable learners to acquire hands-on experiences as well as gain knowledge quickly when doing advanced research topics (Segun et al., 2014).

Sanjeev et al., (2017) in their research titled “tinkering to fabricating - developing basic skills of fabrication in freshmen” indicated that demonstrations done at workshops about the usage of tools were taught during tutorials. To find out the efficiency of tutorials, design projects were introduced. Fifty per cent of the learners concurred that the design project was a fascinating project experience. However, the study was not conducted in TVET institutions in the Kenyan context limiting its generalization.

Faas and Daniel (2013) described an activity that allowed learners to very fast build and test robots within three hours. The robot named, “Mini-Me” served the learners as a starting point to build complex machines later on in their studies. This study indicated that such activities helped to build learners' personalities during the working training period, especially for female learners. This training process where learners are given small bits lowered the anxiety often experienced when designing and building a robot. Based on the survey outcome, the learners were more confident doing the workshops and therefore they could make more complicated robots. However, the study was not conducted amongst TVET institutions in Kenya.

2.3 Summary of literature review

It is clear from document research that different teaching methods are used in different specialized fields such as engineering, medicine and social sciences.

Many of the studies focused on how skills of learners, hands-on experiences, benefits and obstacles of WBL, tutorials, PBL, project-based learning and workshop training skills versus employment as discussed by many authors.

Many of the authors in the document analysis used quantitative methods to analyse data.

Despite the availability of many teaching methods, there was no empirical study that addressed the effects of different active teaching methods either individually or collectively by mechanical engineering graduates in Kenya.

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

This chapter describes the research design, area of the study, the population covered by the study, sampling technics and sample size, data collection process, instruments used, pretesting of the questionnaires, determination of validity and reliability of data collection instruments, the procedure of data collection and data analysis as well as ethical considerations.

3.2 Research design

A research design shows or outlines methods to be undertaken to get the information required to answer or find a solution to a research problem. In other words, it is a plan of how the research will be done (Relivingmbadays, 2015). According to Kothari and Garg (2014), the research design is the process of collecting data, measuring and analyses of data that successfully allows the research operations to be done. This research adopted an explanatory research design. According to Cooper and Schindler (2014), explanatory research is done to research problems that have not been well researched. This type of research answers the "why" questions. In answering the "why" questions, the research develops descriptions. These descriptions asserted that phenomenon Y (acquisition of technical skills) is affected by variable X (teaching methods) and even showed the magnitude of the effects. This research design was selected because it was deemed suitable for answering the research questions and was in line with the research objectives.

3.3 Study area

This research was conducted in western Kenya zones which house the Kenya Association of technical training institutes-western region. The western Kenya region includes Kisii national polytechnic, Kisumu national polytechnic and Sigalagala national polytechnic which are among the eleven national polytechnics in Kenya. This study focused mainly on the national polytechnics that offer the Kenya national examinations council (KNEC) technician diplomas in mechanical engineering.

3.4 Population of the Study

In research, the population is defined as a group from which information is sought. On the other hand, the target population comprises the entire group a researcher wishes to make observations. (Brannen & Gemma, 2012). In this research, the accessible population was 674 trainees and 80 trainers who were drawn from the three national polytechnics in the region which included Kisii national polytechnic, Kisumu national polytechnic and Sigalagala national polytechnic in the western Kenya region. The respondents were drawn from teachers and students as indicated in table 3.1.

Table 3.1 Target population

National polytechnic	Number of Students	Number of teachers
Sigalagala national polytechnic	189	29
Kisii national polytechnic	201	21
Kisumu national polytechnic	284	33
Total	674	80

Source: Administrations of the national polytechnics under study.

3.5 Sampling technique and sample size

The sample size is the number of respondents in research and they are determined by the extent or scope of the study it is based on confidence level and margin of error as explained by Collis and Hussey (2014). According to Martínez-Mesa et al., (2016), a sample frame comprises a list of individuals that define the researcher's population of interest and is selected from the targeted population. In this research, the sample frame incorporated both teachers and students of mechanical engineering from three national polytechnics in the western Kenya region. The cluster random sampling technic was used in the selection of the institutions. Respondents on the other hand were selected by a simple random sampling procedure. This sampling procedure was adopted because the population was geographically spread and the researcher could not access them at once. According to Collis and Hussey (2009), this method is suitable when individuals display variations in the study phenomenon.

In this research, national polytechnics served as larger groups which the specified samples were selected from. The size of each group was proportionately determined. Bullen (2016), says that appropriate sample size is normally about 10% of the population. This research used the table prepared by Krejcie and Morgan (1970) to determine the sample size which was 66 trainers and 248 trainees.

3.5.1 Sampling procedure for mechanical engineering students and teachers

The total number of registered students in the three national polytechnics was six hundred and seventy-four. A sample of 248 students and teachers corresponds to the required sample selected from a population of 674 students according to Morgan and Krejcie's tables (Appendix III). Consequently, the respective samples were proportionately calculated as illustrated in table 3.2.

Table 3.2: Sample size

National polytechnic	No. of registered students	Sample proportion	No. of teachers	Sample proportion
Sigalagala	189	$\frac{189}{674} \times 248$ $= 69.54 \cong 70$	29	$\frac{29}{80} \times 66$ $= 23.93 \cong 24$
Kisii	201	$\frac{201}{674} \times 248$ $= 73.96 \cong 74$	21	$\frac{21}{80} \times 66$ $= 17.33 \cong 17$
Kisumu	284	$\frac{284}{674} \times 248$ $= 104.50$ $\cong 104$	30	$\frac{30}{80} \times 66$ $= 24.75 \cong 25$
Total	674	248	80	66

Source: Administration of the selected national polytechnics

3.6 Research instrument

Questionnaires were the main data collection tool in this research. A questionnaire consists of pre-formulated questions whose main purpose is to get information from respondents in a pre-determined format. The questionnaires provide the researcher with information that can be reviewed in a predefined procedure to develop meaning and make logical conclusions. They help the researcher to get standardized data as explained by Walther (2014). On other hand, Phellas et al., (2011), recommend that when the questionnaires are developed as a data collection instrument, they should be easy to comprehend and easy to respond to. Questionnaires need to have a cover letter in case they are not directly administered by the individual doing the research. Questionnaires are appropriate especially when there are a large number of respondents. Therefore, the questions must be clear, accurate and to the point. The questions must be asked in a consistent way across all the respondents according to Mathers et al.(2007). The questions in this study were designed in line with the constructs of teaching methods namely; work-based teaching and learning, tutorials, problem-based teaching and learning, project-based teaching and learning, workshop training and knowledge acquisition as highlighted in the conceptual framework.

The questionnaires were designed to get satisfaction rates using a psychometric response scale. The respondents were asked to state their degree of agreement to statements structured in five points i.e., very great extent (VGE) = 5, great extent (GE) = 4, moderate extent (ME) = 3, small extent (SE) = 2, and very small extent (VSE) = 1. This scale ensured that the questions asked were fair and not biased. This type of measurement scale assisted to determine the degree or the strength of attitude in a relative manner. This allowed for the collection of standardized information that was expressed numerically for the sake of correlational analysis. The questionnaire items were stated in a positive form with no open-ended questions to get the opinion of the teachers. The researcher delivered the questionnaires to selected national polytechnics with the help of respective heads of departments. The questionnaires had two sections namely; Section A: which contained demographic items and section B, which covered items touching on teaching methods and acquisition of technical skills.

3.7 Pre-testing of research instruments

According to Mugenda and Mugenda (2012), piloting is important in research because it enables the researcher to include all relevant issues are included, there are no ambiguities, pre-coding is alright and there are no omissions. The validity and reliability of research instruments are achieved using the test-re-test method. According to Mathers et al. (2007), a typical procedure in research is to test questionnaires using a smaller number of respondents who possess similar characteristics as those in the sample frame, usually between five to fifty depending on the magnitude of the final sample. It is also allowed to conduct a pre-test on your colleagues when the participants become inaccessible during a pre-testing. In this research, piloting was done to minimize ambiguities, remove repeated questions as well as simplify questions and establish the time required to complete the questionnaire items. Measurement and operationalization of independent and dependent variables were also done during this period. The pilot testing was done at the Eldoret National Polytechnic in Uasin Gishu County.

3.8 Reliability test results

Pilot testing involved a small-scale study that was done at the Eldoret national polytechnic to test the questionnaires for reliability. A small number of twenty-one respondents were given questionnaires but only 16 of them were received by the researcher from both the teachers and students. Cronbach's alpha was applied in the determination of the level of internal consistency of the questionnaire items. The coefficient of reliability of the questionnaires was tabulated in table 4.1.

Table 4.1: Reliability of instruments

Construct	Teachers		Trainees	
	Reliability co-efficient	No of items	Reliability co-efficient	No of items
Work-based learning	0.705	6	0.745	6
Tutorials	0.723	5	0.714	5
Problem-based learning	0.720	5	0.734	5
Project-based learning	0.831	6	0.786	8
Workshop training	0.725	5	0.725	12
Acquisition of technical skills	0.737	6	0.743	6

All the items in the questionnaires had an alpha value that was higher than the minimum acceptable value of alpha which should be at least 0.70 or above as explained by Taber (2018). Therefore, the response items were considered reliable.

3.7.1 Validity of instruments

Validity in research is the degree to which measuring instruments estimate what they assert to measure, Edwards, et al., (2016) while Maisharah, Bahari and Gillani, (2011) also described it as the extent to which useful and meaningful inferences can be derived from data to explain a study problem. Face validity was determined by ensuring that the questionnaire items were in tandem with the conceptual framework (Figure 1.1) which shows all the study variables. The content validity of this research relied mainly on the expert advice of academic supervisors who are the people more experienced in matters of the construct that was measured. The supervisors had access to the questionnaire items and they provided feedback on how best the questions measured the construct. Content validity on the other hand is the degree to which the measuring instruments give accurate and reasonable results from the research in line with the views of Oluwatayo (2012). The researcher conducted a literature review through document analysis from different sources to identify the items that were required to measure the constructs, for example, work-based learning, tutorials, problem-based learning, project-based learning, workshop training and knowledge acquisition. The researcher also consulted the academic supervisors on issues related to the literature review and this served to improve the content validity. The views of the supervisors were incorporated in this study. Construct validity was reviewed many times to reaffirm that the theories applied conformed with the study objectives.

3.7.2 Reliability of instruments

The reliability of study instruments depends on whether or not the measurements were done are reliable, consistent, and stable when the same test is done repeatedly. Cronbach Alpha coefficient is frequently used to measure internal consistency (Taherdoost, 2016). For research to be coherent internally, approximations of reliability should be based on the mean inter-correlations of the items of the study (Van der Linden et al., 2010). After pre-testing at Eldoret National Polytechnic, Cronbach's Alpha of the items or questions in the questionnaires was computed by SPSS version 25 software. Cronbach's Alpha coefficient was established; a value of 0.7 and above was considered high reliability whereas below 0.5 and below was taken as low reliability which is in agreement with Taber (2018).

3.8 Data collection procedure

Before the researcher commenced this research, a permit and an authorization letter were given from the National council for science, technology and innovation (NACOSTI) to the researcher. Copies of the authorization letter were delivered to the county commissioners and county directors of education of the three counties namely; Kisii, Kisumu, and Kakamega Counties informing them about the study and its objectives. This enabled free access to the relevant technical colleges to interview the lecturers and students.

Before the actual commencement, the colleges were visited by the researcher to enlighten and familiarize with the respondents by meeting the heads of departments (HODs) and agreeing on how to administer the questionnaires. Self-administered questionnaires were delivered to the respondents by the researcher within one day of the visit to the institutions.

3.9 Data analysis procedure

All questionnaires were collected, cross-checked and sorted out to remove those with non-responses. The data was given unique codes and entered into the computer applications spreadsheets by using statistical packages for social sciences software (SPSS

V25.0). After coding and entering the dependent and independent variables on SPSS spreadsheets, analyses began by requesting simple descriptive statistics like the frequencies, means and standard deviations.

A five-point Likert scale was applied to be able to determine the strength of an attribute. The lowest score was 1 unit the highest score of 5 units. Consequently, the average of the summed scores also ranged from 1 to 5. To fulfil the equidistance assumption in the Likert Scale, the range on this scale was determined by subtracting the minimum value (1) from the maximum value (5). This gave a value of 4 and this was divided by 5 and the result was 0.8 which gave an equidistance of 0.8 units i.e., $(5-1)/5 = 0.8$. This is in line with Squires et al., (2011) and Orchard et al., (2012). Finally, inferential statistics were run using the same application software.

Descriptive statistics were used for basic characteristics concerning the variables under study and also to give a picture of the relationships within the research variables as highlighted in the conceptual framework. The researcher began by computing sums, frequency distributions central tendencies as well as variability within the study variables. For example, a mean greater than 3.5 means that there is a high level of agreement whereas a mean below 3.5 to 3.0 is considered moderate agreement and if the mean is below 3.0 imply that there is disagreement among the respondents. Descriptive statistics were important because they enabled the researcher to visualize and make some preliminary analyses that enabled simplified data interpretation of the research questions.

The researcher performed inferential statistics using a simple linear multiple linear regression model (equation 3.0) and multiple linear regression model (equation 3.1) which are illustrated hereunder:

a) $y = \beta 0 + \beta 1X1 + \varepsilon$ ……………………………………………………Equation 3.0

b) $y = \beta 0 + \beta 1X1 + \beta 2X2 + \beta 3X3 + \beta 4X4 + \beta 5X5 + \varepsilon$……………..…...Equation 3.1

From these equations y represented dependent variable (acquisition of technical skills) and the independent variables $x_{1,}\ x_2,\ x_3,\ x_4\ and\ x_5$ represented teaching methods, β_{1}- β_5 are the standardized regression coefficients

$\beta 0$ Represented the y-intercept

$X1$ Represents work-based learning

$X2$ Represents tutorials

$X3$ Represents problem-based learning

$X4$ Represents project-based learning

$X5$ Represents work shop training

ε Represents error term

The purpose of inferential statistics was to make accurate deductions and generalizations from the population characteristics. This study also used correlation and regression analysis.

3.9.1 Assumptions of multiple regressions (diagnostic tests)

According to Hlatywayo et al. (2017), it is important to test for normality, multi-collinearity, auto-correlation and homoscedasticity when multiple regressions are conducted. Marchant et al., (2016), also explained that ordinary information is a significant hidden suspicion in the parametric measurable investigation. All parameters should be considered, an assessment of the ordinariness of information is fundamental for some measurable tests in an exploration study. Garson (2012), Kurtosis is the point at which the circulation bend is level or topped. The estimations of skewness and kurtosis ought to be zero in ordinary dissemination insights according to Tabachnick and Fidell (2007). Garson (2012) indicated that information skewness esteems should be within ±1 while kurtosis value should lie within±3. In insights, ordinariness tests are utilized to assess if an informational index is all around displayed by typical dissemination and to work out how likely it is for an arbitrary variable basic the informational collection to be regularly appropriated as explained by Poncet et al., (2016). This research made the following assumptions; the first assumption was that both the independent and dependent variables had a linear relationship. This was ascertained by producing scatterplots. The other assumptions were; there was no multi-collinearity in the data collected, individual data points were independent of each other and finally, homoscedasticity which is the magnitude of error within this model was similar at each point throughout the model.

3.10 Ethical considerations

Ethical considerations were made in this research so that the research was free of manipulation, creation or falsifying of data and therefore this promoted openness and truth which was the main objective of this research. Bell, (2014) insists that when research is conducted, the researcher should be conscious of the possible ethical issue before conducting the study. In respect of this aspect, research authorization was obtained from the National Commission for science, technology and innovation (NACOSTI), subject to authority from the county administrators from the ministry of education and ministry of interior administration from the counties respectively. In this study the respondents participated voluntarily, they had informed consent, and their confidentiality and anonymity were guaranteed. Ethical issues need to be taken into consideration to assure the respondents that; there was no harm in participating in this research, participation was voluntary and this research was purely for academic purposes. The researcher confirmed to the respondents that they could access the finding soon after the research was completed.

CHAPTER FOUR

RESULTS AND DATA ANALYSIS

4.1 Introduction

Data analysis is presented in this chapter on the outcomes of this research which investigated the effects of teaching methods on the acquisition of technical skills in three national polytechnics in the Western Kenya region. This chapter outlines; the response rate, reliability test results, demographic characteristics, age of the respondents, gender, descriptive results and variables. Descriptive statistics done by this research included percentages, means, standard deviations (SD), and comparisons of means and frequencies presented in table format. Multiple regressions and correlation analyses were also done to determine the level of associations and also the degree of variation between the study variables.

4.2 Response rate

Sixty-six trainers and two hundred and forty-eight trainees respectively from the departments of mechanical engineering were sampled. The purpose of the sampling was to get their perceptions of the effect of teaching methods on the acquisition of technical skills in national polytechnics in the western Kenya region. Subsequently, 314 questionnaires were distributed. In total 287 questionnaires were received from the field; 78 questionnaires were not considered or rather were discarded due to lack of response or withdrawal of respondents from the study. This represented a response rate of 66.6% which is within the acceptable range for external validity. According to Denscombe (2014), a percentage greater than 50% is considered adequate or a high rate of response if it is from a small random sample whereas it is a low rate if it is from a big sample. A higher response rate is acceptable because the missing data is not random.

4.4 Demographic characteristics

Demographic information gives information about the respondents and it is important for the determination of whether the research participants form a representative sample of the target population for deriving generalizations according to Salkind (2010). In this research, information regarding the demographic profile captured included: age bracket, gender, the highest level of education and experience in teaching in terms of how many years they have been teaching at TVET or national polytechnics.

4.4.1 Respondents' age bracket

The respondents' age is shown in Table 4.2 below. Most of the trainers (45.2%) were between thirty and forty years while most of the trainees (74.3%) were below thirty years old. The majority of the respondents represented a youthful population which is a global working-age population according to research done by ILO (2020). The respondents in this study were within the working age and therefore provided reliable information in terms of the relevance of technical skills acquired in TVET institutions besides the effectiveness of teaching methods.

Table 4.2: Respondents' age

Age limit	Trainers		Trainees	
	Number	Percentage	Number	Percentage
Less or equal to 30 years.	9	21.2%	124	74.3%
31 to 40 years.	19	45.2%	27	16.2%
41 to 50 years.	6	14.3%	12	7.2%
Above 50 years.	8	19.0%	4	2.4%
Total	42	100%	167	100%

4.4.2 Gender of teachers and students

The results on gender (table 4.3) show that the majority of teachers and students in mechanical engineering were males. The females constituted 31.0% and 31.1% of both teachers and students respectively whereas the males constituted nearly 69 % of the respondents. From the data presented in table 4.3, the ratio of female teachers and students from the departments of mechanical engineering constituted one-third whereas the remaining two-thirds were male. This implies the principle of gender parity in uptake and training of mechanical engineering has not been achieved successfully and thus the decisions made on curriculum design and delivery of mechanical engineering are bound to be gender sensitive. Besides, it underpins the erosion of gender stereotypes in terms of training and teaching engineering. Though mechanical engineering is accessible to all who wish to train and work, this area is still male-dominated.

Table 4.3 Respondents' gender

Category	Teachers		Students	
	Number	Percentage	Number	Percentage
Male	29	69.0%	115	68.9%
Female	13	31.0%	52	31.1%
Total	42	100%	167	100%

4.4.3 The highest level of education for teachers

Among the trainers, the majority had Bachelor's degrees (50.0%) followed by a higher diploma (21.4%), a Master's level of education at 14.3%, a diploma and a PhD at 7.1% each. This outcome implies that the majority of trainers were well educated and could understand what was sought by this study and even interpret the questionnaire well. It also implied that they were well aware of the teaching methods in mechanical engineering. Table 4.4 shows the highest academic grades attained by teachers in the national polytechnics under study.

Table 4.4 Highest academic qualifications of teachers

Level of Education	The number of teachers interviewed	Proportion (%) of teachers based on the total number of people interviewed
PhD	3	7.1
Masters	6	14.3
Bachelors	21	50
Higher Diploma	9	21.4
Diploma	3	7.1
Total	42	100

4.4.4 Work experience of teachers

Table 4.5 shows the distribution of work experience of the teachers. This indicates that, amongst the mechanical engineering teachers,19.0% had work experience of less than 5 years, 28.6% had an experience of between 5 and 10 years, 11.9% had between 11 to 15 years of work experience, 11.9% had work experience between 16 and 20 years while 28.6% had over 20 years of teaching experience. The majority of teachers had served for more than five years. The implication of this is that the respondents had adequate work experience as well as knowledge of the teaching methods in mechanical engineering, they were able to give credible information that the study can rely on. But most importantly, their wealth of experience would ideally also be of benefit to the TVET institutions because it would mean quality work and efficiency in performance.

Table 4.5 Work experience of teachers

Teaching Experience	Frequency (f)	Percentage (%)
Less than 5 years	8	19
Between 5 and 10 years	12	28.6
Between 11 and 15 years	5	11.9
Between 16 and 20 years	5	11.9
Over 20 years	12	28.6
Total	42	100

4.5 Descriptive results of all study variables

The findings from the study were analysed using descriptive statistics such as skewness, kurtosis, variables means and standard deviations. The computed means and standard deviations gave the general impression of how teachers and students perceived the effect of teaching methods on the acquisition of technical skills amongst mechanical engineering students in national polytechnics.

The study utilized multiple Likert-type items where responses were summed together yielding data that was considered interval. The equidistance of 0.8 was distributed across the Likert scale resulting in the following intervals; $1.1 < 1.8$ represented a very small extent (VSE), $1.8 < 2.6$ represented a small extent (SE), $2.6 < 3.4$ represented moderate extent (ME), $3.4 < 4.2$ represented a great extent (GE) and finally $4.2 < 5.0$ represented a very great extent (VGE). The mean was used for interpreting the results of individual items.

4.5.1 Descriptive results for work-based teaching and learning

The study sought to understand the nature and level of WBL in national polytechnics from the teachers' and students' perspectives. This aimed at gaining an understanding of the current state of work-based learning.

4.5.1.1 Teachers' perceptions of work-based learning on the acquisition of technical skills

This research evaluated work-based learning in three national polytechnics from the teachers' perspective. The questionnaire presented six items that were used to measure the perception of teachers on the prevailing status of work-based learning. Frequencies and percentages of the results are summarised in table 4.6. Means and standard deviations for the items are; the projects and assignments required in work-based learning are challenging for the students ($M = 4.24,\ SD = 0.726$), WBL helps learners to maintain academic and occupational circulars up-to-date by regularly integrating school and industry activities ($M = 4.21,\ SD = 0.750$), WBL prepares students to get permanent job opportunities ($M = 4.17,\ SD = 0.824$), WBL provides students with authentic experiences ($M = 4.14,\ SD = 0.783$), WBL provides the students with authentic experiences ($M = 4.12,\ SD = 0.832$), WBL enabled students to familiarize themselves with the work environment, industry terminologies and business protocols ($M = 3.64,$ $SD = 1.008$).

Table 4.6: Teachers' perceptions of the use of work-based learning on technical skills acquisition

Statement	VSE f(%)	SE f(%)	ME f(%)	GE f(%)	VGE f(%)	M	SD
The projects and assignments required in work-based learning are challenging for students.	0.0	0.0	7(16.7)	18(42.9)	17(40.5)	4.24	0.726
Academic and occupational circulars are kept up-to-date by regularly integrating school and industry activities.	0.0	1(2.4)	5(11.9)	20(47.6)	16(38.1)	4.21	0.750
Work-based learning prepares the student to find permanent job opportunities.	0.0	1(2.4)	8(19.0)	16(38.1)	17(40.5)	4.17	0.824
Work-based learning provides the student with authentic experiences.	0.0	1(2.4)	7(16.7)	19(45.2)	15(35.7)	4.14	0.783
Work-based learning method enhances learning quality.	0.0	2(4.8)	6(14.3)	19(45.2)	15(35.7)	4.12	0.832
Enables students to understand the working environment, industry terms and business protocols.	0.0	6(14.3)	13(31.0)	13(31.0)	10(23.0)	3.64	1.008

Key: ***f*** represents frequency**; Likert Scale weights**; 5, 4, 3, 2 and 1 represent; Very Great Extent (VGE), Great Extent (GE), Moderate Extent (ME), Small Extent (SE) and Very Small Extent (VSE) respectively.

4.5.1.2 Students' perceptions of the use of work-based learning on technical skills acquisition

The research evaluated the perception of students in national polytechnics about the work-based learning method of teaching. Table 4.7 summarises the responses to the six questionnaire items used by the researcher to measure the perceptions of students on the prevailing status of work-based learning in national polytechnics amongst mechanical engineering students. The items and their respective means and standard deviations were; the projects and assignments undertaken during WBL were challenging ($M = 4.02$, $SD = 0.818$), school and industry activities are updated regularly ($M = 3.85$, $SD = 1.004$), WBL prepares the students to locate permanent job opportunities ($M = 4.13$, $SD = 0.952$), WBL provides the student with authentic experiences ($M = 4.10$, $SD = 0.816$), the quality of learning is enhanced by WBL and this exposes students to the terminology of work environment and business and industry protocols ($M = 3.69$, $SD = 1.288$).

Table: 4.7 Students' perceptions of the use of work-based learning in the acquisition of technical skills

Statement	VSE *f*(%)	SE *f*(%)	ME *f*(%)	GE *f*(%)	VGE *f*(%)	M	SD
The projects and assignments undertaken during work-based learning are challenging.	0.0	7(4.2)	33(19.8)	77(46.1)	50(29.9)	4.02	0.818
School and industry activities are updated regularly.	1(0.6)	24(14.4)	20(12.0)	76(45.5)	46(27.5)	3.85	1.004
Work-based learning prepares the student to locate permanent job opportunities.	0.0	13(7.8)	27(16.2)	53(31.7)	74(44.3)	4.13	0.952
Work-based learning provides the student with authentic experiences.	0.0	15(9.0)	17(10.2)	76(45.5)	59(45.3)	4.07	0.902
Quality of learning is enhanced by work-based learning.	0.0	10(6.0)	18(10.8)	85(50.9)	54(32.3)	4.10	0.816
Exposes students to the terminology of work environment and business and industry protocols.	15(9.0)	23(13.8)	12(7.2)	65(38.9)	52(31.1)	3.69	1.288

Key: *f* represents frequency**; Likert Scale weights;** 5, 4, 3, 2 and 1 represent; Very Great Extent (VGE), Great Extent (GE), Moderate Extent (ME), Small Extent (SE) and Very Small Extent (VSE) respectively**.**

4.5.2 Descriptive results of tutorials

The research intended to measure the perceptions of both the teachers and students on application tutorials in national polytechnics by mechanical engineering students. This aimed at gaining an understanding of the current state of tutorials as a teaching method.

4.5.2.1 Perceptions of teachers on the use of tutorials in the acquisition of technical skills

The study evaluated the use of tutorials in national polytechnics from the perspective of teachers.

The perception of teachers on the prevailing status of work-based learning in national polytechnics amongst mechanical engineering students was determined by five questionnaire items as presented in table 4.8. The items that were evaluated and their respective means were; in social interaction corrective procedures are intensified to enhance mastery of subject matter ($M = 4.24,\ SD = 0.906$), repeated tests are done to determine the extent to which the students mastered the subject matter ($M = 4.10,\ SD = 0.850$), through the social interaction the student's willingness to question what was not clear increased ($M = 4.17,\ SD = 0.762$), learning is student-centred ($M = 3.88,\ SD = 1.292$) and finally, the student's private interaction with the learning materials increases their intellectual curiosity ($M = 4.14,\ SD = 0.872$).

Table 4.8 Perceptions of teachers on the use of tutorials in the acquisition of technical skills

Statement	VSE *f*(%)	SE *f*(%)	ME *f*(%)	GE *f*(%)	VGE *f*(%)	M	SD
In social interaction corrective procedures are intensified to enhance mastery of subject matter.	1(2.4)	2(4.8)	1(2.4)	20(47.6)	18(42.9)	4.24	.906
Repeated tests are conducted to evaluate the measure students' mastery of the subject matter.	0.0	2(4.8)	7(16.7)	18(42.9)	15(35.7)	4.10	.850
Through social interaction, the student's willingness to question what is not clear has increased.	0.0	1(2.4)	6(14.3)	20(47.6)	15(35.7)	4.17	.762
Learning has been student centred.	5(11.9)	1(2.4)	4(9.5)	16(38.1)	16(38.1)	3.88	1.292
The student's private interaction with the learning materials increases their intellectual curiosity.	1(2.4)	1(2.4)	4(9.5)	21(50.0)	15(35.7)	4.14	.872

Key: *f* represents frequency**; Likert Scale weights;** 5, 4, 3, 2 and 1 represent; Very Great Extent (VGE), great extent (GE), moderate extent (ME), small extent (SE) and very small extent (VSE) respectively.

4.5.2.2 Students' perceptions of learning through tutorials

The study evaluated the perceptions of the use of tutorials by students as a teaching method in national polytechnics and the perceptions were tabulated in table 4.9. Further responses from the five questionnaire items were used to assess students' perceptions of tutorials as a learning method. These items and their corresponding means are; students have the freedom to question what is not clear during the teaching session ($M = 3.87$, $SD = 1.238$), learning is student-centred ($M = 3.94$, $SD = 0.986$), the curiosity to interact with learning materials increased ($M = 3.81$, $SD = 1.027$), the student peers are encouraged to expose their colleagues to concepts they were not able to understand ($M = 4.08$, $SD = 0.898$), the students are encouraged to study privately on their own ($M = 3.57$, $SD = 1.420$).

Table 4.9 Students' perceptions of the use of tutorials in the acquisition of technical skills

Statement	VSE f(%)	SE f(%)	ME f(%)	GE f(%)	VGE f(%)	M	SD
I have the freedom to question what is not clear.	15(9.0)	9(5.4)	22(13.2)	57(34.1)	64(38.3)	3.87	1.238
Learning is student-centred.	1(0.6)	17(10.2)	29(17.4)	64(38.3)	56(33.5)	3.94	0.986
My curiosity to interact with learning materials increased.	6(3.6)	14(8.4)	28(16.8)	76(45.5)	43(25.7)	3.81	1.027
The student peers are encouraged to expose their colleagues to concepts they are not able to understand.	0.0	15(9.0)	16(9.6)	77(46.1)	59(35.3)	4.08	0.898
The students are encouraged to study privately on their own.	29(17.4)	11(6.6)	12(7.2)	66(39.5)	49(29.3)	3.57	1.420

Key: ***f*** represents frequency**; Likert Scale weights;** 5, 4, 3, 2 and 1 represent; very great extent (VGE), great extent (GE), moderate extent (ME), small extent (SE) and very small extent (VSE) respectively.

4.5.3 Descriptive results of problem-based learning

The study sought to understand the nature and level of problem-based learning in national polytechnics from the perspective of teachers and students/trainees. This aimed at gaining an understanding of the current state of problem-based learning as a teaching method.

4.5.3.1 Teachers' perceptions of the use of problem-based learning in the acquisition of technical skills

The study evaluated the use of PBL in national polytechnics as perceived by teachers of national polytechnics in the western Kenya region. The results are presented in table 4.10 the researcher presented 5 questionnaire items for investigating the current state of problem-based learning as a teaching method from the perspective of teachers. The items investigated and their mean values as well as the standard deviations are; that students are actively involved in learning ($M = 4.14$, $SD = 0.872$), problems in the tutorial process are in line with the student's prior knowledge ($M = 4.26$, $SD = 0.665$), the group sizes are appropriate in stimulating learning ($M = 4.14$, $SD = 0.814$), teachers stimulate the students to apply knowledge in other situations ($M = 4.40$, $SD = 0.627$) and finally the teachers are motivated to fulfil their roles ($M = 4.13$, $SD = 0.715$). The detailed results about frequencies and percentages are presented in table 4.10.

Table 4.10 Teachers' perceptions of problem-based learning on the acquisition of technical skills

Statement	VSE f(%)	SE f(%)	ME f(%)	GE f(%)	VGE f(%)	M	SD
Learners are actively engaged during the learning process.	1(2.4)	1(2.4)	4(9.5)	21(50.0)	15(35.7)	4.14	0.872
Problems during the teaching process are in line with the student's prior knowledge.	0.0	0.0	5(11.9)	21(50)	16(38.1)	4.26	0.665
The group sizes are appropriate to stimulate learning.	0.0	2(4.8)	5(11.9)	20(47.6)	15(35.7)	4.14	0.814
Trainers stimulate the students to apply knowledge in other situations.	0.0	0.0	3(7.1)	19(45.2)	20(47.6)	4.40	0.627
The trainers are motivated to fulfil their roles.	0.0	0.0	6(14.3)	17(40.5)	19(45.2)	4.31	0.715

Key: f represents frequency**; Likert Scale weights;** $5, 4, 3, 2$ and 1 represent; very great extent (VGE), great extent (GE), moderate extent (ME), small extent (SE) and very small extent (VSE) respectively.

4.5.3.2 Students' perceptions of the use of problem-based learning in the acquisition of technical skills

The study evaluated the use of problem-based learning in national polytechnics and the perceptions of the students are presented in table 4.11. Five questionnaire items were used to assess the prevailing state of problem-based learning methods from the perspective of the students. From the items evaluated; the students were motivated to fulfil their roles ($M = 3.91$, $SD = 1.366$), students took initiative in diagnosing their learning needs ($M = 4.10$, $SD = 0.889$), students could formulate their learning goals ($M = 4.23$, $SD = 0.694$), real-world problems are related to mechanical engineering world ($M = 3.54$, $SD = 1.536$), and finally, problem-based learning enhanced interest on the subject matter ($M = 3.82$, $SD = 1.281$). A detailed description of individual items in terms of percentages and frequencies is presented in table 4.11.

Table 4.11: Students' perceptions of problem-based learning method

Statement	VSE f (%)	SE f(%)	ME f(%)	GE f(%)	VGE f(%)	M	SD
Our teachers are motivated to fulfil their role of teaching.	21(12.6)	7(4.2)	16(9.6)	45(26.9)	78(46.7)	3.91	1.366
Students take a key role in diagnosing learning needs.	0.0	11(6.6)	25(15.0)	67(40.1)	64(38.3)	4.10	0.889
Students can identify learning objectives.	0.0	3(1.8)	16(9.6)	87(52.1)	61(36.5)	4.23	0.694
Real-world problems are related to the mechanical engineering world.	34(20.4)	12(7.2)	11(6.6)	49(29.3)	61(36.5)	3.54	1.536
Enhances interest in the subject matter.	17(10.2)	9(5.4)	25(15.0)	52(31.1)	64(38.3)	3.82	1.281

Key: f represents frequency. Likert Scale weights; 5, 4, 3, 2 and 1 represent; very great extent (VGE), great extent (GE), moderate extent (ME), small extent (SE) and very small extent (VSE) respectively.

4.5.4 Descriptive results of project-based teaching

The study sought to comprehend the nature and level of project-based learning in national polytechnics from the trainers' and trainees' perspectives. This aimed at getting an interpretation of the current state of project-based learning as a teaching method.

4.5.4.1 Teachers' perceptions of the application of project-based teaching to the acquisition of technical skills

This research evaluated the use of project-based teaching in national polytechnics from the trainers' perspective. The perceptions of the trainers are presented in table 4.12. The teachers' perceptions were measured by six questionnaire items that assessed the prevailing state of project-based learning as a teaching method. These items were; the students try their best even when they are given difficult tasks ($M = 3.43$, $SD = 1.516$), the students could not follow complex instructions unless someone showed them how to do it ($M = 3.24$, $SD = 1.605$), the students valued working with their peers ($M = 4.19$, $SD = 0.773$), the students can gather information from different sources ($M = 3.79$, $SD = 1.071$), the students can plan out projects from start to end ($M = 3.86$, $SD = 1.317$). Finally, when the trainees work hard on something it shows in the results ($M = 4.38$, $SD = 0.492$).

Table 4.12: Trainers' perspective on project-based learning

Statement	VSE *f*(%)	SE *f*(%)	ME *f*(%)	GE *f*(%)	VGE *f*(%)	M	SD
The teachers try their best even when it is a difficult task.	10(23.8)	0.0	6(14.3)	14(33.3)	12(28.8)	3.43	1.516
The students cannot follow complex instructions unless someone shows them how to do them.	12(28.6)	2(4.8)	3(7.1)	14(33.3)	11(26.2)	3.24	1.605
The trainees value working with other students.	0.0	1(2.4)	6(14.3)	19(45.2)	16(38.1)	4.19	0.773
The trainees can gather information from different sources.	3(7.1)	0.0	11(26.2)	17(40.5)	11(26.2)	3.79	1.071
The trainees can plan out projects from start to finish.	5(11.9)	2(4.8)	3(7.1)	16(38.1)	16(38.1)	3.86	1.317
When the trainees work hard on something it shows in the results.	0.0	0.0	0.0	26(61.9)	16(38.1)	4.38	0.492

Key: ***f*** represents frequency; **Likert Scale weights;** 5, 4, 3, 2 and 1 represent agreement to; very great extent (VGE), great extent (GE), moderate extent (ME), small extent (SE) and very small extent (VSE) respectively.

4.5.4.2 Learners' perceptions of the use of project-based learning in the acquisition of technical skills

The study evaluated the use of project-based learning in national polytechnics from the perspective of trainees. As presented in table 4.13. Eight questionnaire items were applied in the assessment of the prevailing state of project-based learning as a teaching method from the students' perspective. The eight items evaluated about project-based learning were; students could make valuable contributions to a project ($M = 4.11$, $SD = 0.911$), students saw challenging problems as tasks they needed to master ($M = 4.16$, $SD = 0.736$), students cared about their projects ($M = 4.10$, $SD = 0.811$), the students could learn from their classmates ($M = 4.34$, $SD = 0.675$), they believed that difficult tasks were beyond their capabilities ($M = 4.20, SD = 0.663$), they kept on trying when things became hard ($M = 4.37$, $SD = 0.605$), they can try harder when the teacher encourages them ($M = 4.22$, $SD = 0.711$) and finally they know what steps to take to solve a problem ($M = 3.44$, $SD = 1.400$).

Table 4.13 Students' perceptions of the use of project-based learning

Statement	VSE f(%)	SE f(%)	ME f(%)	GE f(%)	VGE f(%)	M	SD
I can make valuable contributions to my project.	1 (0.6)	12(7.2)	19(11.4)	71(42.5)	64(38.3)	4.11	0.912
I view challenging problems as tasks to be mastered.	0.0	5(3.0)	19(11.4)	88(52.7)	55(32.9)	4.16	0.736
I care about my project.	0.0	10(6.0)	17(10.2)	86(51.5)	54(32.3)	4.10	0.811
I can learn from my classmates.	0.0	1(0.6)	16(9.6)	75(44.9)	75(44.9)	4.34	0.675
I believe that difficult tasks are beyond my capabilities.	0.0	2(1.2)	17(10.2)	93(55.7)	55(32.9)	4.20	0.663
I keep trying when things get hard.	0.0	2(1.2)	5(3.0)	90(53.9)	70(41.9)	4.37	0.605
I can try harder when the teacher encourages me.	0.0	7(4.2)	14(8.4)	81(48.5)	65(38.9)	4.22	0.771
I know what steps to take to solve a problem.	25(15.0)	25(15.0)	10(6.0)	65(38.9)	42(25.1)	3.44	1.400

Key: f represents frequency**. Likert Scale weights; 5**, 4, 3, 2 and 1 represent agreement to; a very great extent (VGE), great extent (GE), moderate extent (ME), small extent (SE) and very small extent (VSE) respectively.

4.5.5 Descriptive results of workshop training

The study sought to understand the nature and level of workshop training in national polytechnics from the perspective of trainers and trainees. This aimed at gaining an understanding of the current state of work shop training as a teaching method.

4.5.5.1 Teachers' perceptions of the use of workshop training in the acquisition of technical skills

The study evaluated the use of workshop training in national polytechnics from the perspective of trainers. The results were presented in table 4.14.

Five questionnaire items were used to assess the current state of workshop training as a teaching method from the perspective of teachers. The items about workshop training that were evaluated and their means are; they are effective in imparting skills and methods of performing tasks or industry jobs ($M = 4.07$, $SD = 0.601$), the teacher has a chance to perform the demonstrations before the students come to the workshop ($M = 3.98$, $SD = 0.563$), teachers can continually correct and advise the students throughout the workshop practice period ($M = 4.21$, $SD = 0.645$)., teachers maintain contact with all students without distraction ($M = 4.14$, $SD = 0.647$) and finally, spoilt work is minimized after reasonable practice and tuition ($M = 4.00$, $SD = 0.541$).

Table 4.14 Teachers' perceptions of the use of Worksop Teaching in the acquisition of technical skills acquisition

Statement	VSE *f*(%)	SE *f*(%)	ME *f*(%)	GE *f*(%)	VGE *f*(%)	M	SD
Effective in imparting skills and methods of performing tasks or industry jobs.	0.0	0.0	6(14.3)	27(64.3)	9(21.4)	4.07	0.601
The teacher has a chance to perform the demonstrations before the trainees come to the workshop.	0.0	0.0	7(16.7)	29(69.0)	6(14.3)	3.98	0.563
The teachers continually correct and advise the students throughout the whole of the work-shop practice period.	0.0	0.0	5(11.9)	23(54.8)	14(33.3)	4.21	0.645
The teacher maintains contact with all students without distracting.	0.0	1(2.4)	3(7.1)	27(64.3)	11(26.2)	4.14	0.647
Spoilt work is minimized after practice and tuition.	0.0	0.0	6(14.3)	30(71.4)	6(14.3)	4.00	0.541

Key: *f* represents frequency**. Likert Scale weights;** 5, 4, 3, 2 and 1 represent agreement to; a very great extent (VGE), great extent (GE), moderate extent (ME), small extent (SE) and very small extent (VSE) respectively.

4.5.5.2 Learners' perceptions of the use of work shop teaching on the acquisition of technical skills

The study evaluated the use of workshop training in national polytechnics from the perspective of trainees. The perceptions of the students are presented in table 4.15 The perceptions of students were evaluated in respect of the prevailing state of workshop training as a teaching method. Twelve items were evaluated and the respective means were presented as; all student work could be completed and tested within a given period

($M = 3.50$, $SD = 1.452$), workshop scheduled time was strictly followed ($M = 3.59$, $SD = 1.123$), the students took workshop practice seriously ($M = 4.23$, $SD = 0.734$), adequate resources were provided for workshop practice ($M = 3.73$, $SD = 1.268$), workshop classes were not overloaded ($M = 3.87$, $SD = 1.208$), there was adequate guidance on the design project ($M = 4.11$, $SD = 0.912$), sheet metal exercises were adequately practiced ($M = 4.12$, $SD = 0.949$), various tools were demonstrated and students practiced how to use them ($M = 4.05$, $SD = 0.904$), teachers used all tools needed for fabrication which were demonstrated during the training sessions ($M = 3.69, SD = 1.392$), scrap materials are reused effectively during workshop practicals ($M = 4.16$, $SD = 0.852$), there was theoretical skills learning as well as practical knowledge occurring at the same session during workshop practice ($M = 4.05$, $SD = 1.108$) and finally instead of overburdening reports trainers only presented fabricated products which satisfied the objectives of design project ($M = 4.02$, $SD = 0.818$). The degree of agreement to the individual items can be viewed in table 4.15.

Table 4.15 Workshop training from the perspective of trainees

Statement	VSE ƒ(%)	SE ƒ(%)	ME ƒ(%)	GE ƒ(%)	VGE ƒ(%)	M	SD
All student work is completed and tested within a given period.	27(16.2)	22(13.2)	10(6.0)	57(34.1)	51(30.5)	3.50	1.452
Workshop practice scheduled time is strictly followed.	21(12.6)	14(8.4)	26(15.6)	58(34.7)	48(24.7)	3.59	1.123
Students take workshop practice seriously.	0.0	5(3.0)	15(9.0)	84(50.3)	63(34.7)	4.23	0.734
Adequate resources are provided for workshop practice.	12(7.2)	26(15.6)	12(7.2)	62(37.1)	55(32.9)	3.73	1.268
Work shop classes are not overloaded.	6(3.6)	29(17.4)	10(6.0)	57(34.1)	65(38.9)	3.87	1.208
There is adequate guidance on the design project.	1(0.6)	12(7.2)	19(11.4)	71(42.5)	64(38.3)	4.11	0.912
Sheet metal exercises are adequately practised.	0.0	13(7.8)	27(16.2)	54(32.3)	73(43.7)	4.12	0.949
Various tools are demonstrated and trainees practice how to use them.	1(0.6)	11(6.6)	25(15.0)	72(43.1)	58(34.7)	4.05	0.9.04

Trainers have used all tools needed for fabrication which were demonstrated during sessions.	24(14.4)	14(8.4)	9(5.4)	63(37.7)	57(34.1)	3.69	1.392
Scrap materials are reused effectively during workshop practicals.	0.0	8(4.8)	25(15.0)	66(39.5)	68(40.7)	4.16	0.852
Theoretical as well as practical skills occur at the same time as workshop training takes place.	8(4.8)	12(7.2)	14(8.4)	63(37.7)	70(41.9)	4.05	1.108
Instead of overburdening reports, trainers only present finished products that satisfy the objectives/goals of the project design.	0.0	7(4.2)	33(19.8)	77(46.1)	50(29.9)	4.02	0.818

Key: f represents frequency. **Likert Scale weights**; 5, 4, 3, 2 and 1 represent; very great extent (VGE), great extent (GE), moderate extent (ME), small extent (SE) and very small extent (vse) respectively.

4.5.6 Descriptive results of the acquisition of technical skills by mechanical engineering students

This research investigated the nature and level of acquisition of technical skills by mechanical engineering students in national polytechnics from the perspective of trainers and trainees. The aim was to gain an understanding of the current state of acquisition of technical competencies by mechanical engineering trainees as an outcome of the instructional methods used.

4.5.6.1 Teachers' perceptions of the acquisition of technical skills by mechanical engineering students

This research evaluated the perceptions of trainers on the acquisition of technical skills by mechanical engineering students in national polytechnics. The results are presented in table 4.16. The teachers' perceptions of the current state of work shop training as a teaching method were measured by six questionnaire items. The overall mean in terms of the agreement was ($M = 3.92, SD = 0.487$). The individual items are ranked as; students were able to remember or retrieve previously learned material ($M = 3.95$, $SD = 0.795$), the teachers could use learned material, or implement the material in new and concrete situations ($M = 3.90$, $SD = 0.692$), teachers can distinguish the parts of material into its components so that its organizational structure is better understood ($M = 3.83, SD = 0.881$), the trainees can perform engineering tasks based on the acquired knowledge ($M = 3.76$, $SD = 0.850$), the teachers can design materials and outputs based on changing technology ($M = 3.81, SD = 0.833$) and that learners can display their technical skills ($M = 4.26, SD = 0.587$). The corresponding degrees of agreement of the items in terms of frequencies and percentages are presented in table 4.16.

Table 4.16 Teachers' perceptions of the acquisition of technical skills by mechanical engineering students

Statement	VSE *f*(%)	SE *f*(%)	ME *f*(%)	GE *f*(%)	VGE *f*(%)	M	SD
Remembering or retrieving previously learned material	0.0	1(2.4)	11(26.2)	19(45.2)	11(26.2)	3.95	0.795
The capability to apply what they learnt and implement the knowledge and skills in real-life situations.	0.0	1(2.4)	9(21.4)	25(59.5)	7(16.7)	3.90	0.692
Ability to identify components or the parts of material into its components so that its structures may be better understood.	0.0	5(11.9)	5(11.9)	24(57.1)	8(19.0)	3.83	0.881
Ability to perform engineering tasks based on the acquired knowledge	0.0	4(9.5)	9(21.4)	22(52.4)	7(16.7)	3.76	0.850
The trainers can design materials and outputs based on changing technology.	0.0	4(9.5)	7(16.7)	24(57.1)	7(16.7)	3.81	0.833
Learners can display their technical skills	0.0	0.0	3(7.1)	25(59.5)	14(33.3)	4.26	0.587

Key: *f* represents frequency**; Likert Scale weights;** 5, 4, 3, 2 and 1 represent; very great extent (VGE), great extent (GE), moderate extent (ME), small extent (SE) and very small extent (VSE) respectively.

4.5.6.2 Students' perceptions of the acquisition of technical skills

The study evaluated the acquisition of technical skills by mechanical engineering students in national polytechnics from the perspective of trainees as presented in table 4.17. Six questionnaire items were used to assess the current state of workshop training as a teaching method from the perspective of students which had an overall mean ($M = 3.96$, $SD = 0.433$). The means of the items were; learners can display their technical skills ($M = 3.95$, $SD = 0.714$), learning packages provide updated information that meets modern industrial needs ($M = 3.92$, $SD = 0.659$), learning methods add value to the engineering education courses ($M = 4.00$, $SD = 0.720$), learning package has applicable information to meet both the technical and vocational education and the industrial objectives ($M = 3.94$, $SD = 0.647$), their intellectual curiosity increases ($M = 3.86$, $SD = 0.747$) and learners can use the acquired knowledge in designing an experiment ($M = 4.08$, $SD = 0.711$).

Table 4.17 Students' perceptions of the acquisition of technical skills

Statement	VSE f(%)	SE f(%)	ME f(%)	GE f(%)	VGE f(%)	M	SD
Learners can display their technical skills.	0.0	4(2.4)	35(21.0)	94(56.3)	34(20.4)	3.95	0.714
The learning package provides updated information to meet modern industrial needs.	1(0.6)	2(1.2)	31(18.6)	108(64.7)	25(15.0)	3.92	0.659
The learning method adds value to engineering education courses.	3(1.8)	2(1.2)	19(11.4)	111(66.5)	32(19.2)	4.00	0.720
The learning package has applicable information to meet both the technical and vocational education and industrial objectives.	0.0	3(1.8)	31(18.6)	106(63.5)	27(16.2)	3.94	0.647
The intellectual curiosity of the learners has increased.	3(1.8)	3(1.8)	33(19.8)	104(62.3)	24(14.4)	3.86	0.747
The trainee can use acquired knowledge to design an experiment.	0.0	1(.6)	33(19.8)	85(50.9)	48(28.7)	4.08	0.711

Key: *f* represents frequency**; Likert Scale weights** 5, 4, 3, 2 and 1 represent agreement to; Very Great Extent (VGE), Great Extent (GE), Moderate Extent (ME), Small Extent (SE) and Very Small Extent (VSE) respectively.

4.5.6.3 Paired samples test for the acquisition of technical skills by mechanical engineering students

Paired sampled test was used to give the hypothesis test results for comparing the perception of acquisition of technical skills amongst mechanical engineering students according to trainers and trainees. The study hypothesized that was no significant difference in perception of acquisition of technical skills in the two groups. From table 4.18, there was no significant mean difference in perception of acquisition of technical skills between trainers and trainees($t41 = 0.996, p > 0.001$). On average, the perception of the acquisition of technical skills of trainees' scores was .087 points higher than trainers' scores ($95\,\%\,CI\ [-0.090, .264]$). However, there is a need for more detailed attention to optimizing teaching methods to engender much more intensive acquisition of technical skills amongst engineering students. This underscores the potentiation of both students' and teachers' involvement in the instructional framework and teaching method as a way of accounting for the perceptions of stakeholders in the acquisition of skills (Könings et al., (2014).

Table 4.18 Paired samples test for the acquisition of technical skills amongst mechanical engineering students of trainers and trainees

	Paired Differences							
				95% Confidence Interval of the Difference				
	Mean	Std. Dev.	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Trainees-Trainers	0.087	0.568	0.088	-0.090	0.264	0.996	41	0.325

From the Paired Sample Correlation table 4.19, it is clear that the perception of acquisition skills among mechanical engineering students of trainers and trainees are not significantly correlated (*r* = .137, $p > 0.001$).

Table 4.19: Paired Samples acquisition of technical skills amongst mechanical engineering students of trainers and trainees

	N	Correlation	Sig.
Trainees-Trainers	42	0.137	0.389

4.6 Predictive analysis

Assumptions of multiple regression analysis were first tested and then multiple regressions were done to determine the effect of teaching methods on the acquisition of technical skills in national polytechnics in the western Kenya region.

4.6.1 Assumption of normality

The normality should be determined by skewness and kurtosis statistics (Tabachnick., 2013). According to Kim (2013), data Skewness values should be ±1.00 and kurtosis should be in the range of ±3.00. If the data passes both then the data is considered normally distributed and does not have a skewed distribution. The results in table 4.20 show that the normality assumption was supported since the Skewness and Kurtosis range of values were within the stated ranges.

Table 4.20: Test results of normality

	Skewness	Kurtosis
Construct	Statistic	Statistic
Work-based teaching	-0 .848	0.752
Tutorial teaching	- 0.596	-0.142
Problem-based teaching	- 0.455	-0.565
Project-based teaching	0.391	0.431
Work shop teaching	-0.494	-0.533
Technical skills acquisition	-0 .690	-1.019

A histogram is a good pictorial presentation of how data is distributed (Field, 2009). Therefore, histograms were also used in this study to test for normality in the data analysis. Regression and ANOVA assumed that the data were normally distributed. The researcher evaluated by checking how far the data deviated from a bell-shaped normal distribution as illustrated in figures (4.1, .4.2, 4.3 4.4, .4.5 and 4.6).

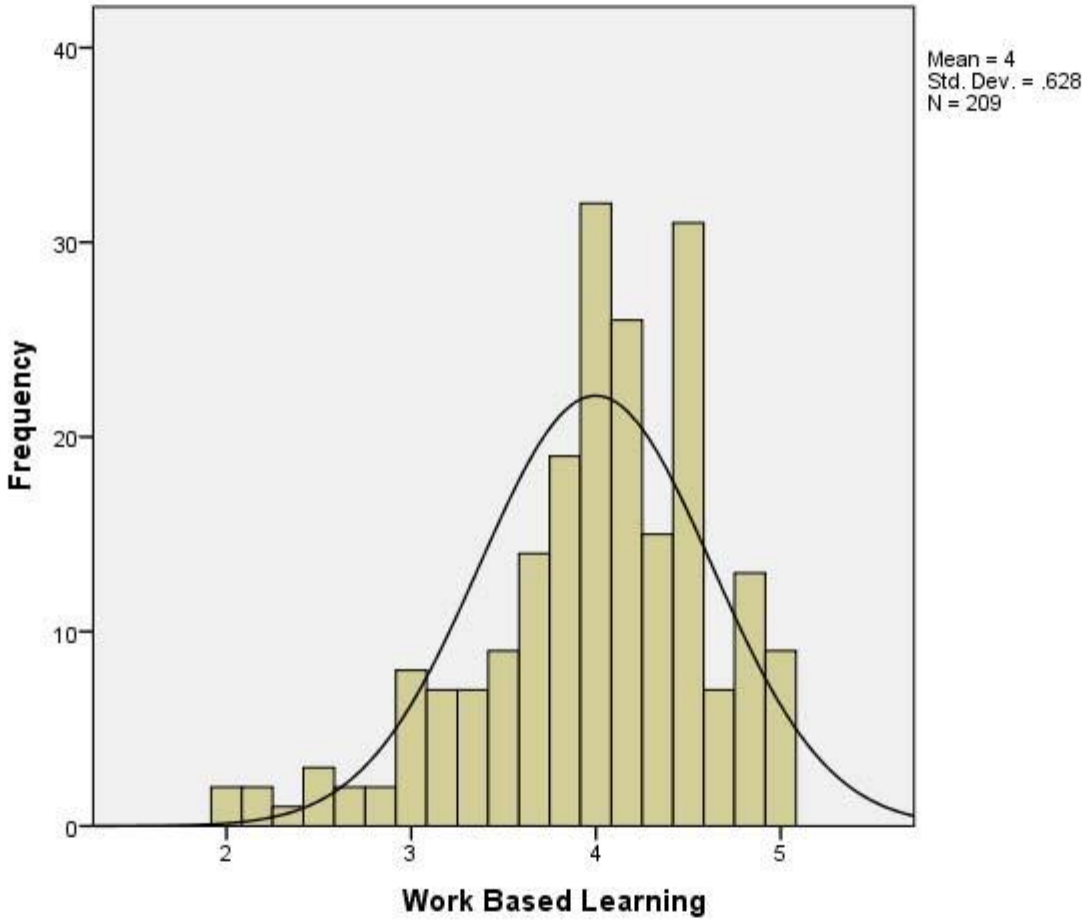


Figure 4.1 Work-based learning

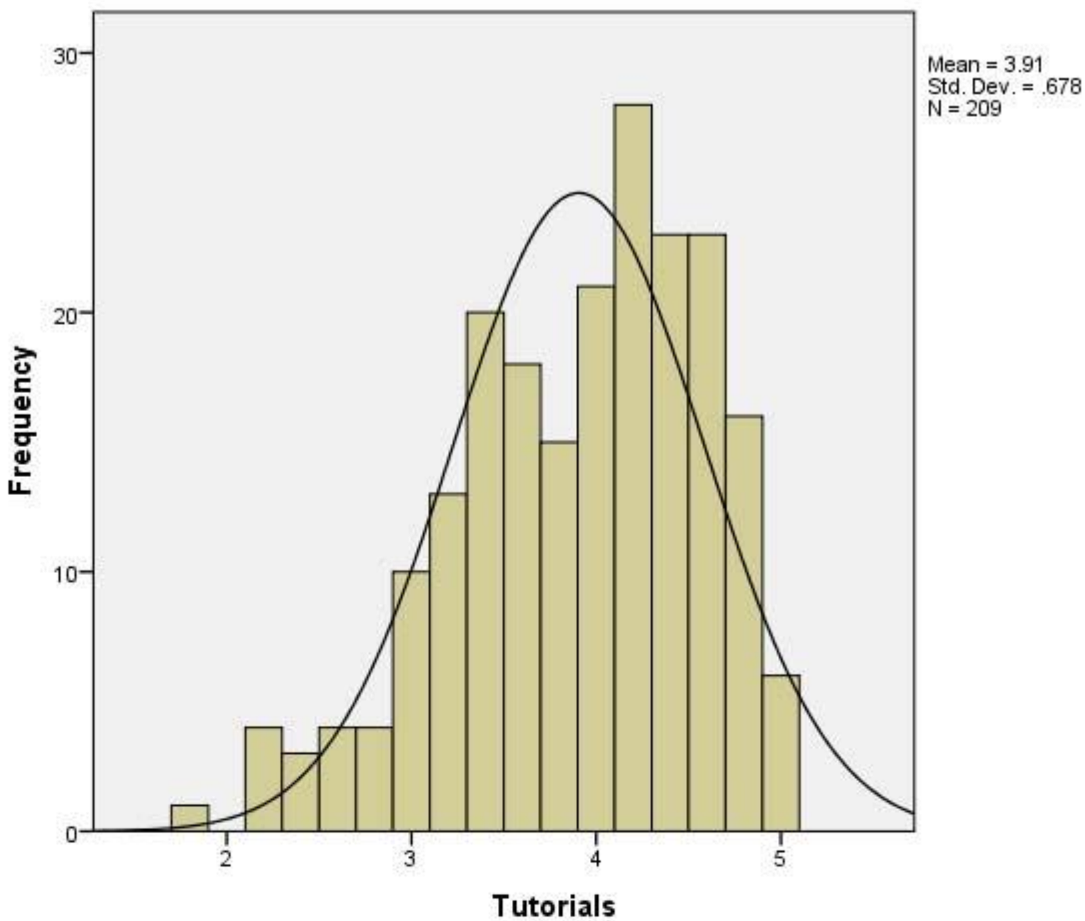


Figure 4.2 Tutorials

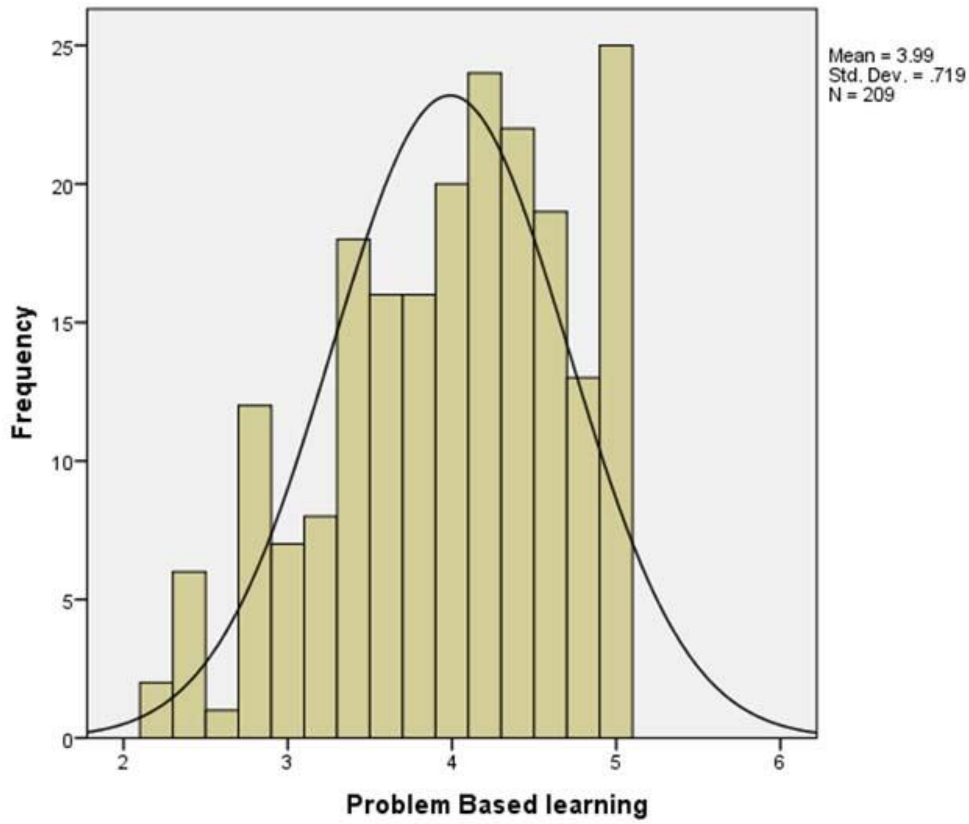


Figure 4.3 Problem-based learning

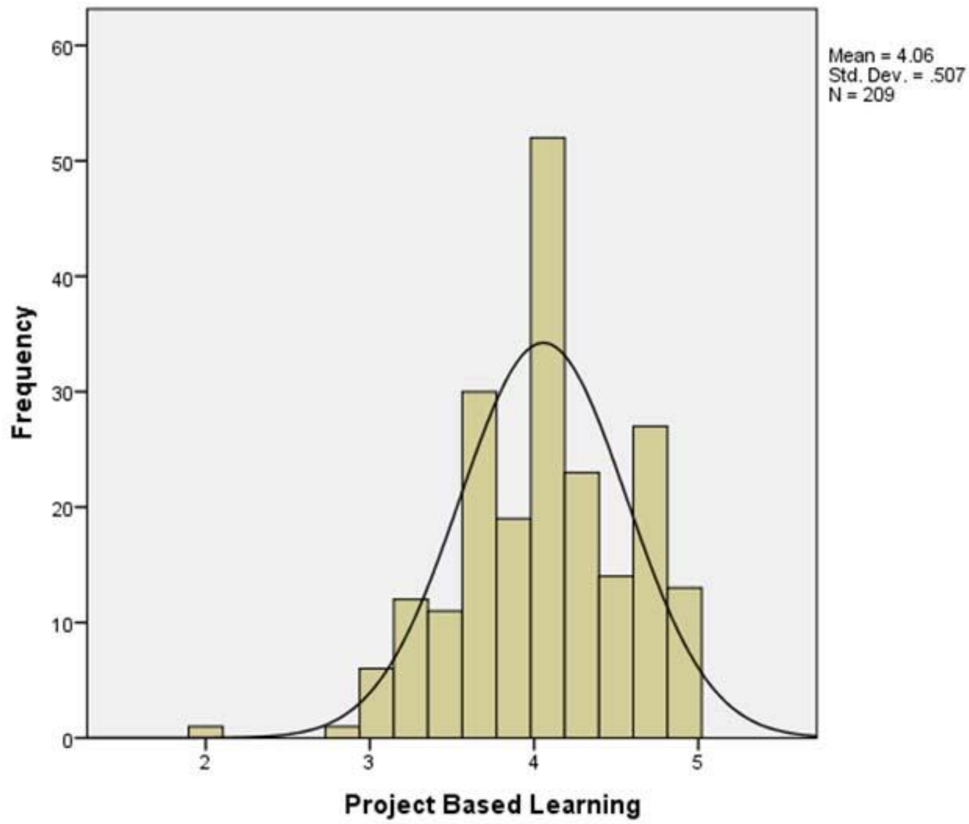


Figure 4.4 Project-based learning

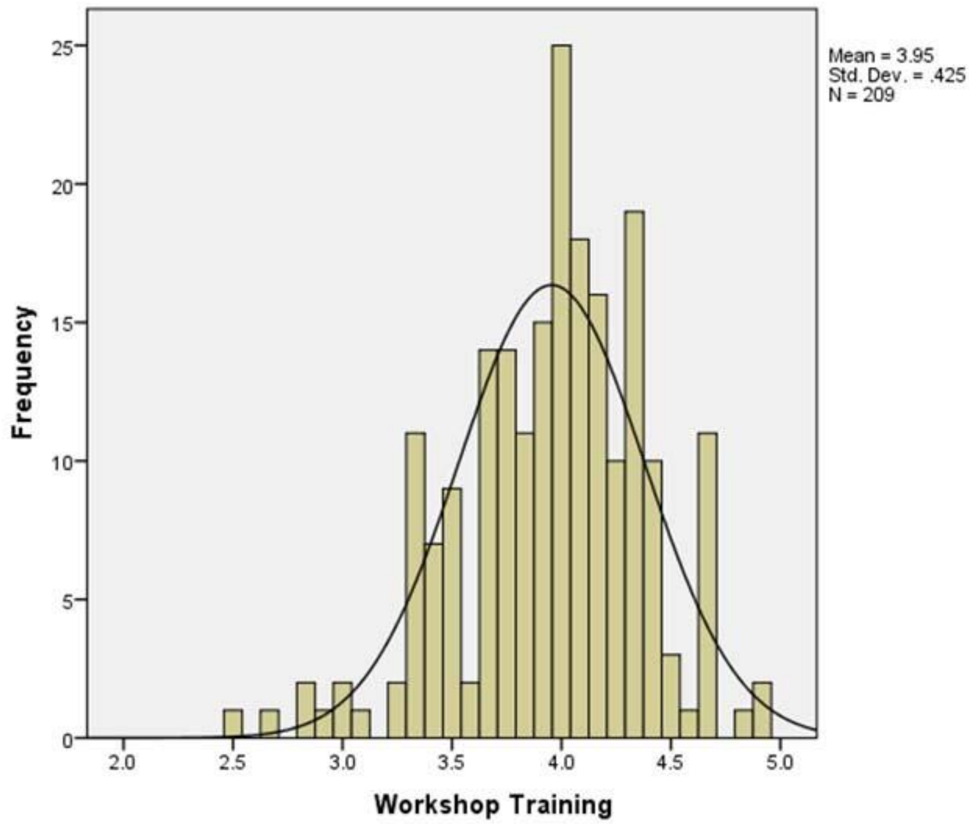


Figure 4.5 Workshop training

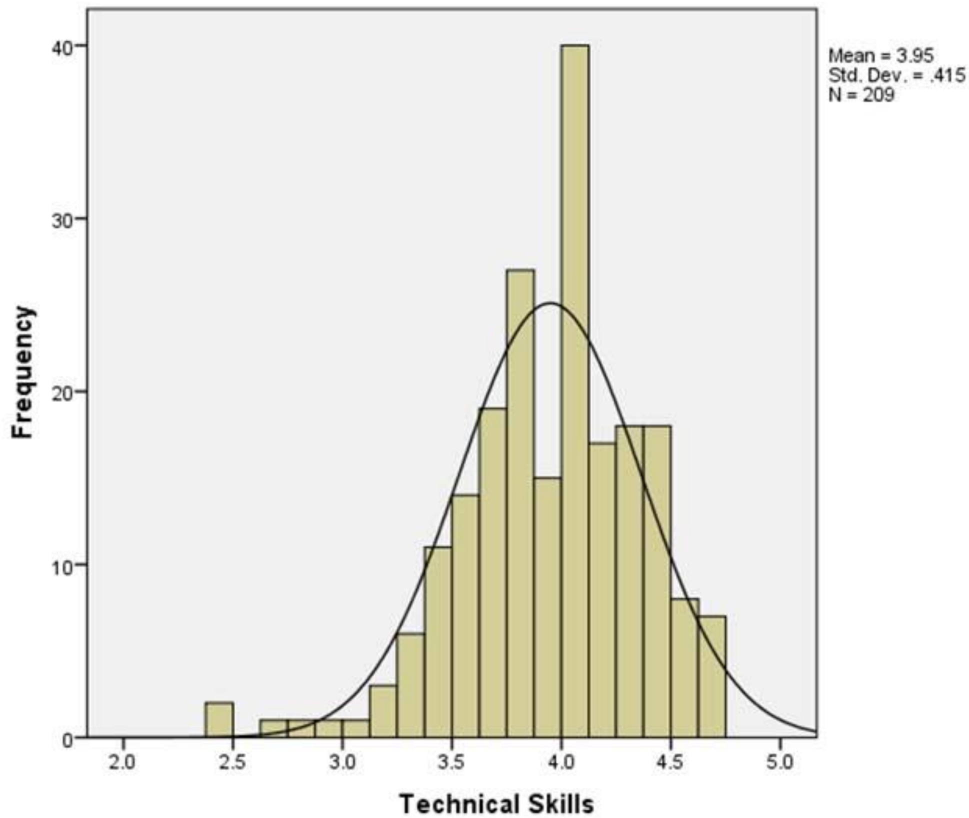


Figure 4.6 Technical skills

4.6.2 Assumption of linearity

The linearity of the data was tested by Pearson's correlation coefficients, to identify teaching methods in mechanical engineering that could give good predictions for regression analysis. Table 4.21, shows the inter-correlations within the study variables. It is clear from the outcome that correlations within the teaching methods in mechanical engineering were significant. Correlation coefficients between work-based learning, tutorials, problem-based learning, project-based learning and work shop training were; r =0 .557** r =0 .576**, r =0 .612**, r = 0.529** and r = 0.504** respectively. The correlation coefficients imply that they were positive and significantly related to the acquisition of technical skills in mechanical engineering with $P < 0.01$. The key assumptions of Linearity were taken into account and therefore all the teaching methods in mechanical engineering under study jointly had a positive and significant impact on the acquisition of mechanical engineering technical skills in national polytechnics. The management and trainers in national polytechnics should put a lot of emphasis on these teaching methods to enhance the acquisition of mechanical engineering technical skills.

Table 4.21: Test results of linearity

	Work-based learning	Tutorials	Problem-based learning	Project-based learning	Workshop training	Technical Skills
Work-based learning	1					
Tutorials	0.274**	1				
Problem-based learning	0.232**	0.544**	1			
Project-based learning	0.202**	0.332**	0.449**	1		
Work shop training	0.625**	0.261**	0.204**	0.162**	1	
Technical Skills	0.557**	0.576**	0.612**	0.529**	0.504**	1

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

*. Correlation is significant at the 0.05 level (2-tailed).

4.6.3. Multicollinearity

The correlation matrix was obtained and checked for multicollinearity. When the correlation coefficient between a factor and itself the value is always 1 and therefore that's why the main diagonal in the correlation matrix is 1 (table 4.21). This implies that a matrix with 1s in the main diagonal is an identity matrix and therefore there was no multicollinearity as explained by Kothari and Garg (2014). According to Tabachnick and Fidell (2001), the Variance Inflation Factor (VIF), determines the impact of collinearity among variables in a regression model. VIF values greater than 10 are usually interpreted as the presence of Multicollinearity (Osborne & Waters, 2002). According to table 4.39 Variance Inflation Factor (VIF), tolerance is within the threshold ranges hence no multicollinearity.

4.6.4. Autocorrelation

When linear regression analysis is done the assumption is that there is little or no autocorrelation in the data. This can happen when the residuals are not independent of one another according to Tabachnick and Fidell (2001). In this research, the linear regression model was tested by the Durbin-Watson test. From the results of table 4.36, the Durbin-Watson was 1.733 which was within the range hence there was no autocorrelation.

4.6.5. Homoscedasticity

Homoscedasticity means that the variances of all the observations are identical to one another, heteroscedasticity means the variances of all the observations are different (Allison, 2015). A scatter plot reveals the relationships or associations between two variables. The scatter plots in figure 4.7 to figure 4.11 revealed an approximately linear relationship between the acquisition of technical skills in mechanical engineering and the predictors revealed a statistical condition of heteroscedasticity. For a heteroscedastic data set, the variation in the dependent variable differs depending on the values of predictors. The use of heteroscedastic data still provides an unbiased estimate of the relationship between the predictor and the dependent variable as explained by Ginker and Lieberman (2017).

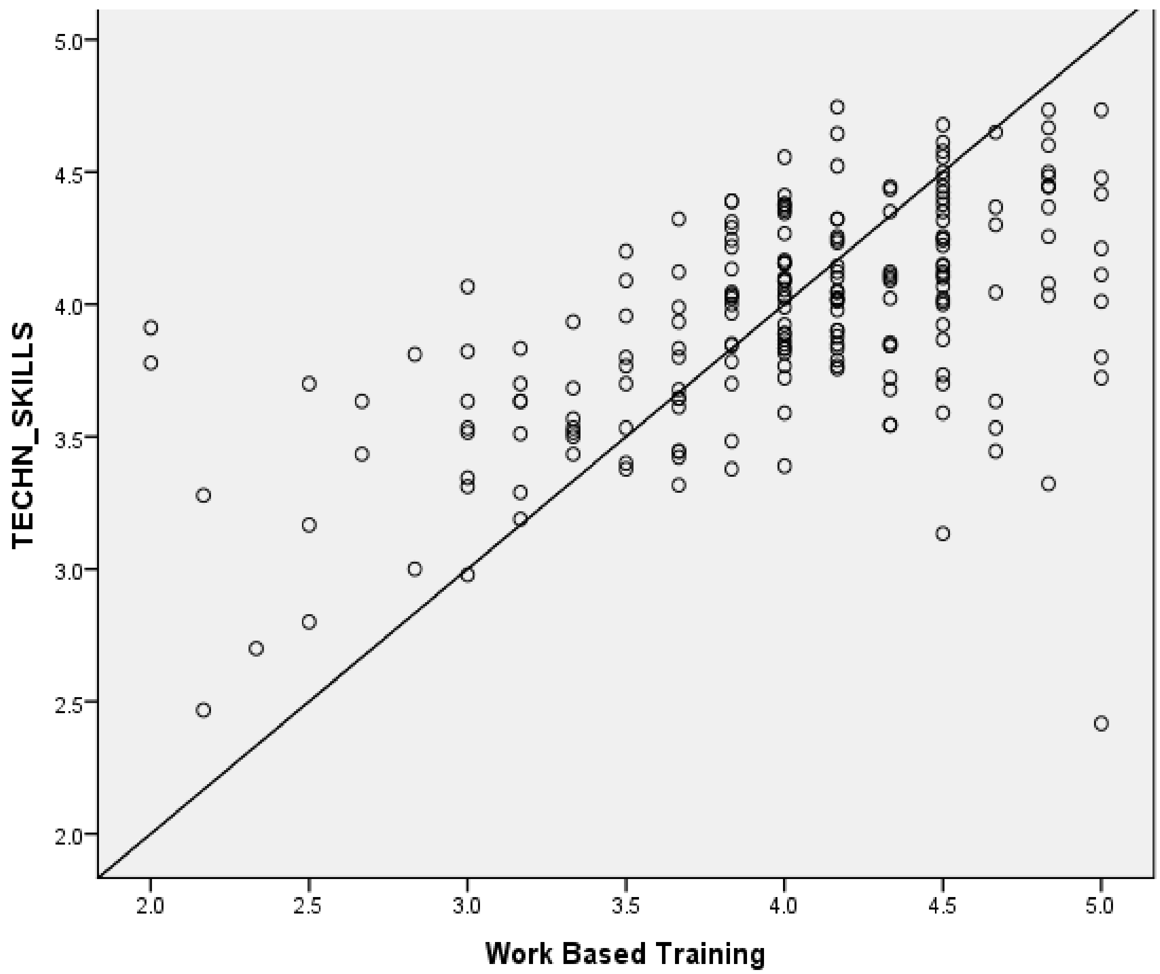


Figure 4.7 Scatter plot for work-based training

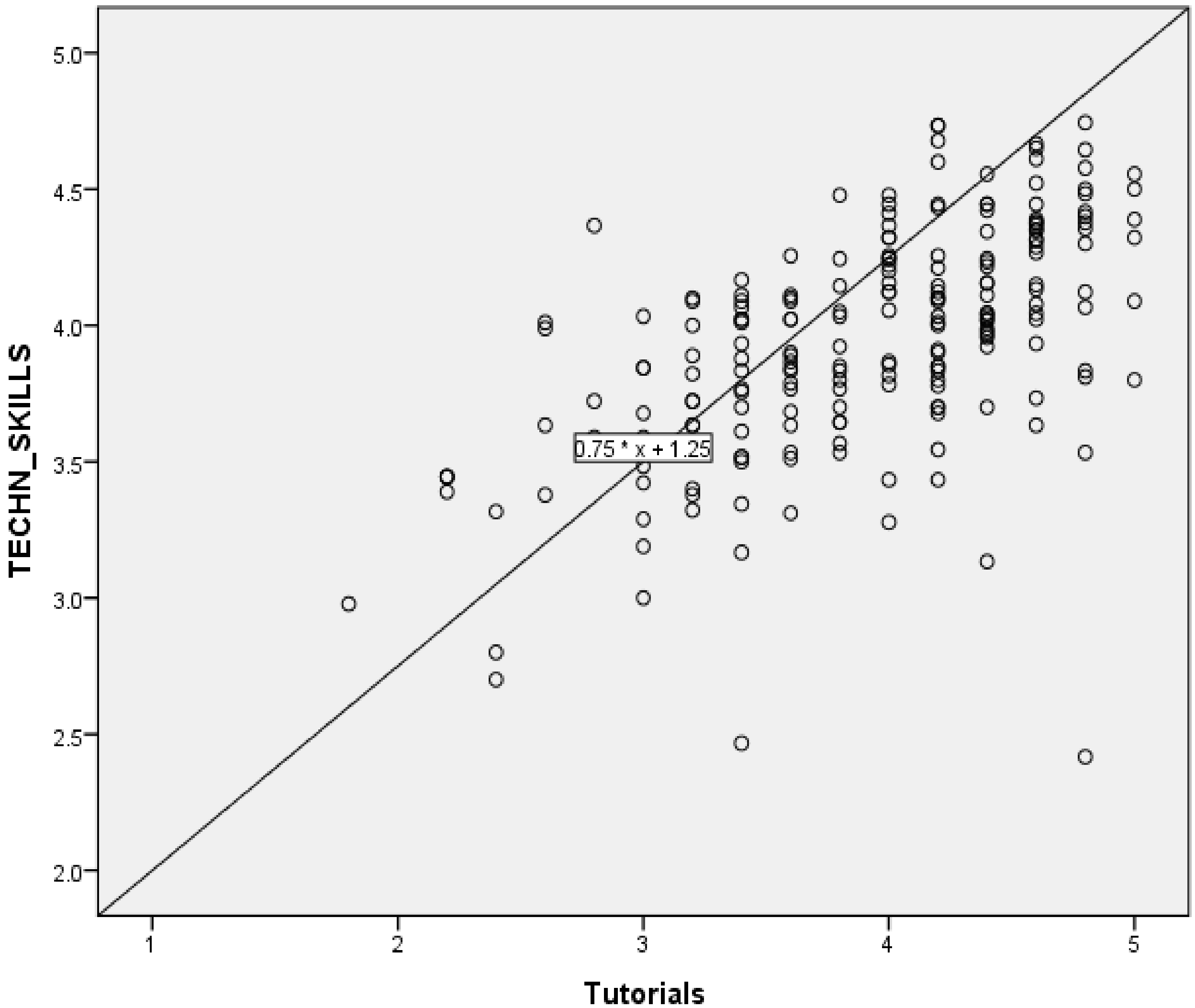


Figure 4.8 Scatter plot for tutorials

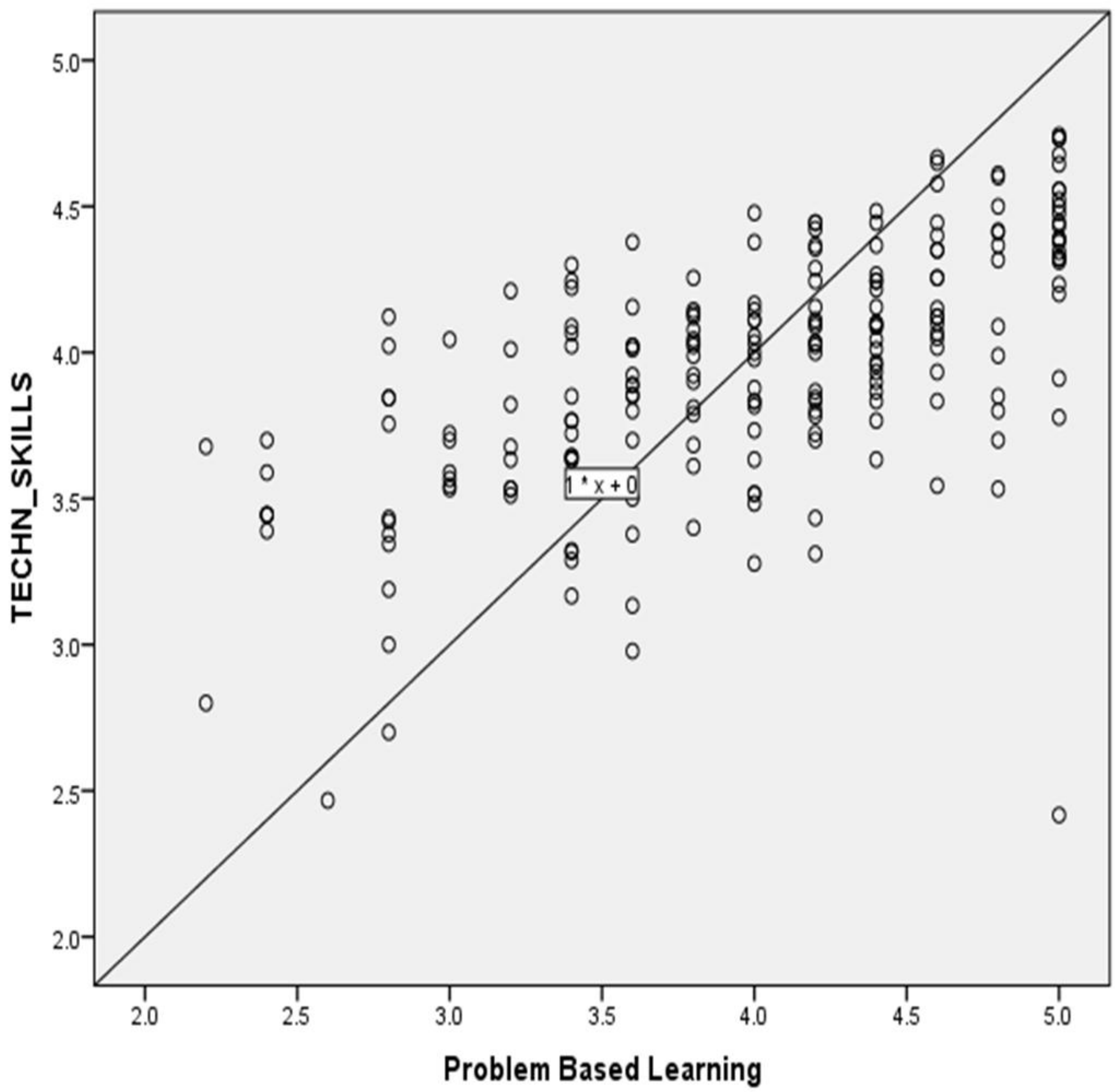


Figure 4.9 Scatter plot for problem-based learning

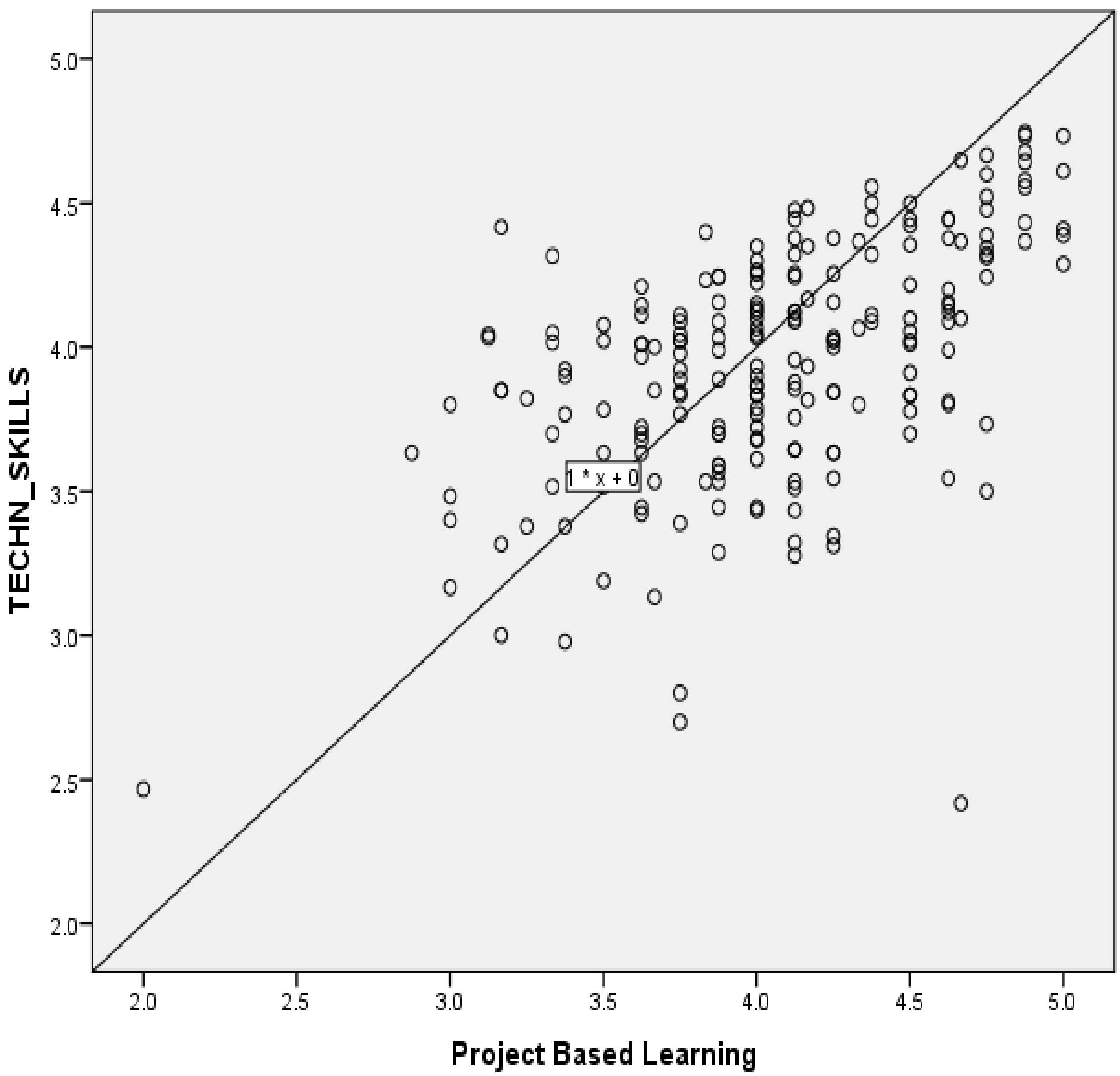


Figure 4.10 Project-based learning

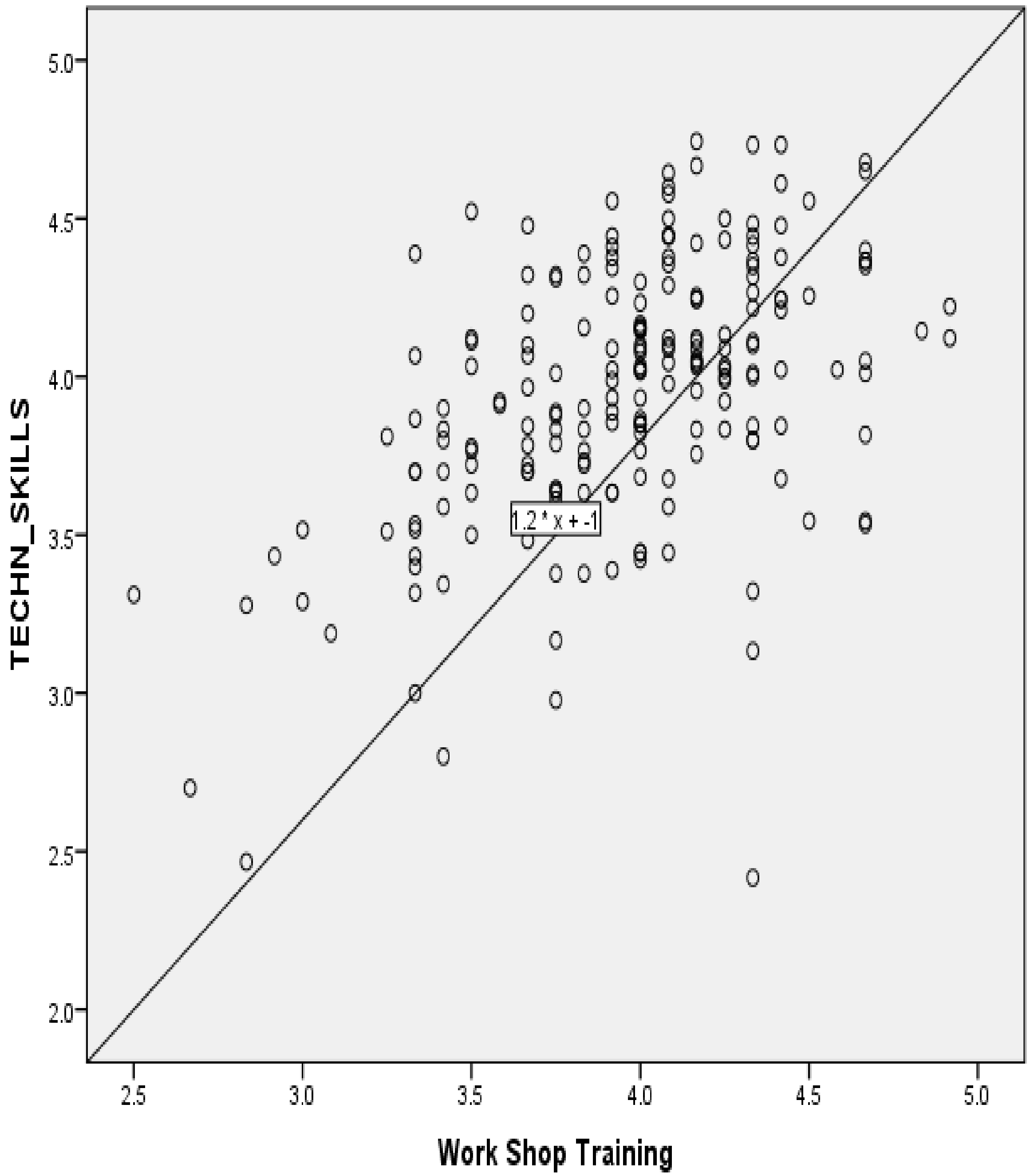


Fig 4.11 Scatter plot for work shop training

4.7 Regression analysis

The study identified work-based learning, tutorials, problem-based learning, project-based learning, and workshop training as the imperative instructional methods that determined the acquisition of technical skills in mechanical engineering as revealed in the literature review. The independent variables were subjected to simple linear regression analysis (SLRA) and multiple regression analysis (MRA) to find out their effect on the acquisition of technical skills in mechanical engineering which was the dependent variable.

4.7.1 Effects of work-based learning on the acquisition of technical skills amongst mechanical engineering students

Table 4.22 shows a model summary of work-based learning as the only independent variable.

Table 4.22 Model summary for work-based learning regression

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	0.557[a]	0.311	0.307	0.346	1.879

a. Predictors: (Constant), Work-based learning

b. Dependent Variable: acquisition of technical skills

The coefficient R^2 of determination (R^2 = 0.311) implies that the model explained only 31.1 % of the total variation in the dependent variable while 68.9 % could be explained by other factors apart from work-based learning. Adjustment of R^2 could not change the results significantly, having reduced the explanatory behaviour of the predictor to 30.7%. ANOVA was used to check whether the proposed model was viable as depicted in table 4.23.

Table 4.23 Regression model Goodness of Fit test results for work-based learning

Model		Sum of squares	df	Mean square	F	Sig.
1	Regression	11.142	1	11.142	93.330	0.000[b]
	Residual	24.712	207	0.119		
	Total	35.854	208			

a. Dependent variable: acquisition of technical skills

b. Predictors: (Constant), Work-based learning

Table 4.23 indicated that the overall model was significant in explaining the acquisition of technical skills, $F (1, 207) = 93.330, p<0.01$) confirming that the model was valid. This model significantly improved the predictability of acquisition of technical skills in mechanical engineering and therefore the model was fit.

4.7.1.1 Regression coefficients of work-based learning

The regression coefficients are shown in Table 4.24. The table shows the estimates of β values and gives work-based learning contributions to the model.

Table 4.24 Regression coefficient of work-based learning

Model	Unstandardized coefficients B	Std. Error	Standardized coefficients Beta	T	Sig.	Collinearity Statistics Tolerance	VIF
1 (Constant)	2.476	0.154		16.043	.000		
Work Based Learning	0.368	0.038	0.557	9.661	0.000	1.000	1.000

a. Dependent Variable: acquisition of technical skills

The β value gives the relationship between the acquisition of technical skills in mechanical engineering with the predictor, work-based teaching. Work-based learning has a significant effect on the acquisition of technical skills, $t\ (16) = 16.03, p < 0.05$. The positive β value implies that there existed a positive relationship between work-based learning and acquisition of technical skills in mechanical engineering. The unstandardized coefficient for the acquisition of technical skills in mechanical engineering (0.368) was positive. The positive β value indicates the direction of the relationship between the predictor and outcome. From the results in table 4.24, the model was then specified as: -

$y = \beta 0 + \beta 1 X1 + \varepsilon$ ………………………………………………………Equation 4.1

Acquisition of technical skills $= 2.476 + 0.368 *$ Work-based learning

The coefficient of the variable indicates the amount of change one could expect in the acquisition of technical skills given a one-unit change in work-based learning based on the unstandardized coefficients. Results of the unstandardized regression coefficient for work-based learning (β=0.368), imply that an increase of 1 unit in work-based learning is likely to result in a 0.368 unit increase in the acquisition of technical skills in mechanical engineering. T-test was used to test whether the predictor made a significant contribution to the model.

Based on the research question;

What is the perception of work-based learning/ teaching on the acquisition of technical skills amongst mechanical engineering students in national polytechnics in the western Kenya region?

When the t-test associated with β value is significant then the predictor has a significant contribution to the model. The results show that work-based learning is (t =9.661, P<.01). In this regard the findings explain that work-based learning significantly affects the acquisition of technical skills in mechanical engineering amongst students in national polytechnics.

4.7.2 Effects of tutorials on the acquisition of technical skills amongst mechanical engineering students in national polytechnics

The model summary presented in table 4.25 involves tutorials as the only independent variable. In this case, R^2; the coefficient of determination = 0.332. A linear regression model was fitted to explain the acquisition of technical skills based on tutorials as a teaching method. This model explained 33.2% of the variation in technical skills acquisition by mechanical engineering students. The overall model is significant in explaining technical skills acquisition.

Table 4.25: Model summary of tutorials

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	0.576[a]	0.332	0.328	0.340	1.545

a. Predictors: (Constant), Tutorials

b. Dependent Variable: Acquisition of technical skills

Results shown in Table 4.26 revealed that the F-statistic was highly significant. The ANOVA output $F\,(1, 207) = 102.74,\ P < 0.05$ means that the model was reliable. The model significantly improved the ability to predict the acquisition of technical skills among mechanical engineering students.

Table 4.26: Regression ANOVA table results for tutorials

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	11.893	1	11.893	102.747	0.000[b]
	Residual	23.961	207	0.116		
	Total	35.854	208			

a. Dependent Variable: Technical Skills

b. Predictors: (Constant), Tutorials

4.7.2.1 Regression coefficients of tutorials

Results of the regression coefficients presented in Table 4.27 shows the estimates of β values and the individual contribution of the tutorial variable to the model.

Table 4.27 The significance of the effect on tutorials

	Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
Model	B	Std. Error	Beta	T	Sig.	Tolerance	VIF
(Constant)	2.571	0.138		18.633	0.000		
Tutorials	0.353	0.035	0.576	10.136	0.000	1.000	1.000

a. Dependent Variable: acquisition of technical skills

The positive β value indicates a positive relationship between the predictor and the outcome. The β value for the acquisition of technical skills (0.353) was positive. The positive β values indicate the direction of the relationship between tutorials and the acquisition of technical skills amongst mechanical engineering students. From the results in table 4.27, the model was then specified as: -

$y = \beta 0 + \beta 2X2 + \varepsilon$ …………………………………………………………. Equation 4.2

Acquisition of technical skills $= 2.571 + (0.353 *$ Tutorials)

The coefficient of the variable indicates the amount of change one could expect in the acquisition of technical skills given a one-unit change in tutorials based on the unstandardized coefficients. From the results the unstandardized regression coefficient for tutorials (β=0.353), implies that with a 1 unit increase in tutorials the acquisition of technical skills amongst mechanical engineering student increases by 0.353 which is a significant change t (16) =10.136, $p<0.05$.

Based on the research question; what is the effect of tutorials on the acquisition of technical skills amongst mechanical engineering students in national polytechnics in the western Kenya region?

A T-test was used to answer the research questions by checking if tutorials made a significant effect on the model. From the t test, the value of β is significant when the predictor variable makes a significant contribution to the model, in this case, tutorials did (t =10.136, P<.01). It can be inferred that tutorials significantly affect the acquisition of technical skills amongst mechanical engineering students.

4.7.3 Effect of problem-based learning on the acquisition of technical skills amongst mechanical engineering students in national polytechnics

The model summary presented in table 4.28 involves problem-based learning as the only independent variable.

Table 4.28 Model Summary of problem-based learning

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	0.612[a]	0.375	0.372	0.329	1.628

a. Predictors: (Constant), Problem based learning

b. Dependent Variable: acquisition of technical skills.

The R^2: coefficient of determination = 0.375 in this model implied that the model explained only 37.5 % of the total variation in the acquisition of technical skills amongst mechanical engineering students while the remaining 62.5 % could be explained by other factors other than problem-based learning. The adjustment of R^2did not change the results significantly, having lowered the explanatory behaviour of problem-based learning to 37.2%. ANOVA results of the model are presented in table 4.29.

Table 4.29 Regression ANOVA table of results for problem-based learning

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	13.445	1	13.445	124.191	0.000[b]
	Residual	22.409	207	0.108		
	Total	35.854	208			

a. Dependent Variable: Acquisition of technical skills

b. Predictors: (Constant), Problem based learning.

This linear regression model was fitted to explain the acquisition of technical skills based on a problem-based learning methodology. All assumptions of this model were met. The results of this model are significant in explaining the acquisition of technical skills, $F(1, 207) = 124.191$, $p<0.01$).

4.7.3.1 Regression coefficients of problem-based learning

Results of the regression coefficients presented in Table 4.31 shows the relationship between the acquisition of technical skills amongst mechanical engineering students with the predictor being, problem-based learning.

Table 4.30 Regression coefficients of problem-based learning

Model		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
		B	Std. Error	Beta	T	Sig.	Tolerance	VIF
1	(Constant)	2.538	0.129		19.735	0.000		
	Problem-based learning	0.354	0.032	0.612	11.144	.000	1.000	1.000

a. Dependent Variable: Acquisition of technical skills

b. Predictors: (constant) Problem-based learning

The positive β value indicates a positive relationship between the predictors and the outcome. The β value for the acquisition of technical skills amongst mechanical engineering students (.354) was positive and significant ($p<0.01$). From the results in table 4.30, the model was then specified as:

$y = \beta 0 + \beta 3X3 + \varepsilon$ ……………………………………………………Equation 4.3

Acquisition of technical skills =2.538+ 0.354 *Problem-based learning

The coefficient of the problem-based learning variable indicates the amount of change one could expect in the acquisition of technical skills amongst mechanical engineering students given a one-unit change in problem-based learning based on the unstandardized coefficients. The unstandardized regression coefficient for problem-based learning (β=0.354), implies that an increase of 1 unit in problem-based learning is likely to result in a 0.354 unit increase in the acquisition of technical skills amongst mechanical engineering students.

Based on the research question; what is the perception of problem-based teaching on the acquisition of technical skills amongst mechanical engineering students' national polytechnics in the western Kenya region?

A T-test was used to examine if problem-based teaching made a significant contribution to the model to answer the research question. The results show that problem-based learning is (t =11.144, P<.01). In this regard it can be inferred that problem-based teaching significantly affected the acquisition of technical skills amongst mechanical engineering students.

4.7.4 Effects of project-based learning on the acquisition of technical skills amongst mechanical engineering students in national polytechnics

Table 4.31 shows project-based learning as the independent variable and acquisition of technical skills as the dependent variable in a model summary output.

Table 4.31 Model summary of project-based learning

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	0.529a	0.279	0.276	0.353	1.628

a. Predictors: (Constant), project-based learning

b. Dependent Variable: acquisition of technical skills

The coefficient of determination (R^2 = 0.279) indicated that this model explained 27.9 % of the total variations in the acquisition of technical skills among mechanical engineering student's variations while the remainder of 72.1 % could be explained by other factors apart from project-based learning. By adjusting R^2 , there was no significant change, having reduced the explanatory behaviour of the predictor to 27.6%. The ANOVA output of this model is presented in table 4.31.

From the results in table 4.32, the model is valid since the F-statistic is significant F (1,207) = 80.275, p <0.01. The model could significantly predict the acquisition of technical skills.

Table 32 Regression ANOVA table of test results for project-based learning

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	10.019	1	10.019	80.275	0.000[b]
	Residual	25.835	207	0.125		
	Total	35.854	208			

a. Dependent Variable: acquisition of technical skills

b. Predictors: (Constant), project-based learning

4.7.4.1 Regression coefficients of project-based learning

Table 4.33 gives the regression coefficients that show the relationship between the acquisition of technical skills amongst mechanical engineering students with the predictor being project-based learning

Table 33 Regression coefficients of project-based learning

	Unstandardized coefficients		Standardized coefficients			Collinearity statistics	
Model	B	Std. Error	Beta	T	Sig.	Tolerance	VIF
(Constant)	2.194	0.197		11.116	.000		
Project-based learning	0.433	0.048	0.529	8.960	0.000	1.000	1.000

a. Dependent Variable: acquisition of technical skills

When the β value is positive, it means that there exists a positive relationship between the predictor and the outcome. The β value for the acquisition of technical skills amongst mechanical engineering students (0.433) was positive and significant ($p<0.01$). Table 4.32 represents the results of the model presented as: -

$y = \beta 0 + \beta 3 X 3 + \varepsilon$ .... ……………………………………………………………Equation 4.4

Acquisition of technical skills $= 2.194 + 0.433 *$ project-based learning

The coefficient of the project-based learning variable shows the magnitude of change expected in the acquisition of technical skills amongst mechanical engineering students given a one-unit change in project-based learning based on the unstandardized coefficients. The unstandardized regression coefficient for project-based learning (β=0.433), means that a 1 unit increase in project-based learning causes an increase of 0.433 units in the acquisition of technical skills amongst mechanical engineering students.

Based on the research question; what is the perception of project-based teaching on the acquisition of technical skills amongst mechanical engineering students in national polytechnics in the western Kenya region?

A T-test was used to examine if project-based learning made a significant effect on the model. The results indicated that project-based learning had a significant effect (t =8.860, P<.01). In this regard the research question was answered that project-based learning significantly affects the acquisition of technical skills amongst mechanical engineering students.

4.7.5 Effects of work shop training on the acquisition of technical skills amongst mechanical engineering students in national polytechnics

Table 4.34 shows the model summary of the results of workshop training as the independent variable.

Table 4.34: Model summary of workshop training

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	0.504[a]	0.254	0.250	0.360	1.642

a. Predictors: (Constant), Workshop training method

b. Dependent Variable: Acquisition of technical skills

R: the correlation coefficient = 0.504 while the coefficient of determination $R^2 = 0.254$.

From these results, the model could explain only 25.4 % of the variation of the dependent variable (acquisition of technical skills amongst mechanical engineering students) and the difference of 74.6 % could be explained by other factors apart from workshop training. The Durbin-Watson value = 1.642 as a measure of correlation was considered relatively normal. The adjustment of R^2 did not change the results significantly, having reduced the explanatory behaviour of the predictor to 25.0%. Table 4.34 shows the ANOVA output that was used to check whether the proposed model is significantly useful in explaining the acquisition of technical skills.

Table 4.35: Regression ANOVA table results for the workshop training method

Mode l	Sum of Squares	df	Mean Square	F	Sig.
Regression	9.100	1	9.100	70.408	0.000[b]
Residual	26.754	207	0.129		
Total	35.854	208			

a. Dependent Variable: Acquisition of technical skills

b. Predictors: (Constant), Work shop training method

From Table 4.35 the overall model is significantly useful in explaining the acquisition of technical skills F (9.1, 207) = 70.408 p<0.01). The model was therefore considered valid. The model significantly improved the ability to predict the acquisition of technical skills.

4.7.5.1 Regression coefficients of work shop training method

Results of the regression coefficients presented in Table 4.36 explain the relationship between the acquisition of technical skills amongst mechanical engineering students with the predictor, workshop training method.

Table 4.36: Regression coefficients of workshop training method

Regression model	Unstandardized coefficients B	Std. Error	Standardized coefficients Beta	T	Sig.	Collinearity statistics Tolerance	VIF
(Constant)	2.002	.233		8.582	0.000		
Workshop Training Method	0.492	0.059	0.504	8.391	0.000	1.000	1.000

c. Dependent Variable: Acquisition of technical skills

The positive β value indicates a positive relationship between the predictors and the outcome. The β value for the acquisition of technical skills amongst mechanical engineering students (0.492) was positive and significant ($p < 0.01$). From the results (table 4.35) the model was then specified as: -

$y = \beta 0 + \beta 3 X3 + \varepsilon$ .... ……………………………………………………………Equation 4.5

Acquisition of technical skills $(y) = 2.002 + 0.492 *$workshop training method

The coefficient of the workshop training method variable indicates the amount of change one could expect in the acquisition of technical skills amongst mechanical engineering students given a one-unit change in the workshop training method based on the unstandardized coefficients. The results of the unstandardized regression coefficient for the workshop training method (β= 0.492), imply that an increase of 1 unit in the workshop training method is likely to result in a 0.492 unit increase in the acquisition of technical skills amongst mechanical engineering students.

Based on the research question; What is the perception of workshop training on the acquisition of technical skills amongst mechanical engineering students in national polytechnics in the western Kenya region?

A T-test was used to examine if the workshop training method was making a significant contribution to the model. The results show that the workshop training method is ($t = 8.391$, $P < 0.01$). In this regard, the research question was answered workshop training significantly affected the acquisition of technical skills amongst mechanical engineering students.

4.7.6 Effect of teaching methods on the acquisition of technical skills amongst mechanical engineering students in national polytechnics

The model summary of multiple regression results is presented in table 4.37.

Table 4.37: Model summary of teaching methods and acquisition of technical skills regression

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	0.819[a]	0.671	0.662	0.241	1.733

Predictors: (Constant), work-based learning, tutorials, problem-based learning, project-based learning and workshop teaching methods

Dependent Variable: acquisition of technical skills

Based on the research question: What is the combined effect of work-based, tutorials, problem-based learning, project-based and workshop training in national polytechnics in the western Kenya region? Multiple linear regression was used to explain the acquisition of technical skills based on work-based learning, tutorial teaching, problem-based learning, project-based learning and workshop training method. All assumptions were met and from the analysis of the results; R multiple correlation coefficient = 0.819, while R^2 the coefficient of determination = 0.671 implied that all the five predictors (work-based learning, tutorials, problem-based learning, project-based learning and workshop training method) jointly explained 67.1% of the total variation in the dependent variable (acquisition of technical skills) among mechanical engineering students.

Table 4.38 Regression Model Goodness of Fit Test results of teaching methods and acquisition of technical skills regression

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	24.043	5	4.809	82.653	0.000[b]
	Residual	11.810	203	0.058		
	Total	35.854	208			

a. Dependent Variable: acquisition of technical skills

b. Predictors: (Constant), work-based learning, tutorials, problem-based learning, project-based learning and workshop training method

The overall model is significantly useful in explaining the acquisition of technical skills, $F(5, 203) = 82.653$, $p < 0.00$. This indicates that the regression model is a good fit for the data; hence, the joint contribution of the (teaching methods) independent variables was significant in predicting the acquisition of technical skills among mechanical engineering students.

4.7.6.1 Regression coefficients of teaching methods

Results of the regression coefficients presented in table 4.39 show the estimates of Beta values and give the contribution of each predictor in the model.

Table 4.39: Overall regression analysis

Model	Unstandardized Coefficients *B*	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	T	Sig.	Collinearity Statistics Tolerance	Collinearity Statistics VIF
(Constant)	0.549	0.193		2.840	0.005		
Work-based learning	0.178	0.035	0.269	5.137	0.000	0.591	1.693
Tutorials	0.134	0.030	0.219	4.448	0.000	0.668	1.497
Problem-based learning	0.164	0.030	0.284	5.551	0.000	0.620	1.613
Project-based learning	0.200	0.037	0.245	5.367	0.000	0.781	1.281
Workshop training	0.176	0.051	0.181	3.476	0.001	0.601	1.664

a. Dependent Variable: acquisition of technical skills in mechanical engineering.

The Beta value for work-based learning(0.178), tutorials (0.134), problem-based learning (0.164), project-based learning (0.200) and workshop training method (0.176) were all positive and significant. The *B* values are positive and they show the direction of the relationship between teaching methods and the acquisition of technical skills. Table 4.38 presents the model results can then be summarized as: -

$Y = 0.549 + 0.178X1 + 0.134X2 + 0.164X3 + 0.200X4 + 0.176X5$..... Equation 4.6

Where, $X1, X2, X3, X4$ and $X5$ represent work-based learning, tutorials, problem-based learning, and project-based learning respectively.

The coefficients of the variables indicate the magnitude of change expected in the acquisition of technical skills in mechanical engineering for a one-unit change of teaching method according to the unstandardized coefficients. For example; the unstandardized regression coefficient for work-based learning (β=0.178) means that a 1 unit increase in teaching methods gives rise to 0.178 units increase in acquisition of technical skills while the other variables in the model are held constant. For tutorials (β=0.134), problem-based learning (β=0.164), project-based learning (β=0.200), workshop training (β=0.176). From the purpose of this research, it can be inferred that teaching methods affect the acquisition of technical skills by mechanical engineering students in national polytechnics. A T-test was used to determine if the predictors made a significant contribution to the model. If the t-test related to the Beta value is significant then the predictor is significant to the model. The findings of this study show that work-based learning (t =5.137, P< 0.01), tutorials (t =4.448, P< 0.01), problem-based learning (t =5.551, P< 0.01), project-based learning (t =5.367, P< 0.01) and workshop training method (t =3.476, P < 0 0.01).

4.8 Chapter Summary

In this chapter data analysis, results, findings and discussion were presented. There was a response rate of 66.6% which is within the acceptable range for external validity. The coefficient of reliability of the questionnaires was higher than the minimum acceptable value of alpha which should be at least 0.70 or above. Demographic data on the age of respondents, gender, the highest level of education and work experience information gives information about the respondents and it is important for the determination of whether the research participants form a representative sample of the target population to derive generalizations. The study used descriptive statistics such as skewness, kurtosis, variables means and standard deviations to provide a general picture of how the trainers and trainees perceived the effect of teaching methods on the acquisition of technical skills amongst mechanical engineering trainees in national polytechnics. From both the trainers' and trainees' perspectives all the teaching methods namely work-based learning, tutorials, problem-based learning, project-based learning and workshop training are in use in TVET institutions. Besides the study used simple and multiple regression analysis after testing for its assumptions and Pearson's correlation and established that all the teaching methods namely work-based learning, tutorials, problem-based learning, project-based learning and work shop training had a significant and positive effect on the acquisition of technical skills in TVET institutions as premised on both constructivism and cognitive learning theory.

CHAPTER FIVE

DISCUSSIONS

5.1 Introduction

This chapter presents the sum of findings conclusions and recommendations derived for further research on an assessment of the effect of teaching methods on the acquisition of technical skills for mechanical engineering trainees in three national polytechnics (Kisii, Kisumu and Sigalagala) in the western Kenyan region. The study concluded that teaching methods significantly affect the acquisition of technical skills of mechanical engineering trainees from the three national polytechnics. When combined all the teaching methods under study had a significant positive effect on the acquisition of technical skills in mechanical engineering in national polytechnics compared to the use of a single method.

5.2 Summary of findings and discussions

The main goal of this research was to determine the degree or extent to which teaching methods influenced the acquisition of technical skills by mechanical engineering students in national polytechnics. The study sought to assess the extent to which work-based learning, tutorials, problem-based learning, project-based learning and workshop training influence the acquisition of technical skills. From this study, it was found that teaching methods significantly affected the acquisition of technical skills by mechanical engineering students.

5.2.1 Effect of work-based learning on the acquisition of technical skills

Work-based learning had a positive significant effect on the acquisition of technical skills of mechanical engineering trainees (F= 93.330; p<0.01) as illustrated by table 4.23. The R^2 ; coefficient of determination $R^2 = 0.311$) represented by table 4.22 implied that this model explained 31.1 % of the total variation in the acquisition of technical skills for mechanical engineering trainees. The unstandardized regression coefficient for work-based learning (β=0.368) implies that work-based learning increases the acquisition of technical skills in mechanical engineering. These findings are supported by the findings of Ondieki et al., (2018) Haruna et al., (2019) and the European training foundation (ETF)., (2013). In this regard, workplace learning is increasingly being used as a learning place for youths and adults in occupational training and educational programs.

These findings are premised on Constructivist theory which considers the learner as an active agent in the process of knowledge acquisition. This theory underscores that learning is structured around events that facilitate the development of knowledge and skills. Therefore, work-based learning should be structured around activities that enhance the acquisition of technical skills in mechanical engineering. Thus, national polytechnics and other TVET institutions should consider incorporating work-based learning as part of their response to the need for the acquisition of technical skills inclined toward the employability agenda. Work-based learning is therefore a recipe for education relevant to the Job requirement and transition from school to work

Teachers are encouraged to be open-minded and be ready for new skills that could enhance occupational and workplace competencies. Teachers need a broad range of instructional methodologies that are in line with the needs of national and local requirements in the Kenyan context by working collaboratively with local industries.

5.2.2 Effect of tutorials on the acquisition of technical skills

The Goodness of Fit test result from table 4.26 indicated that the F statistic was highly significant ($F= 102.747$, $p<0.01$) and this mean the model was reliable. From table 4.25, the coefficient of determination was 0.332 representing 33.2 % of the total variation in the acquisition of technical skills of mechanical engineering students. This finding has supported the studies of Cousins et al., (2012); Cheng et al., (2011) and Harasim, (2017) who reported a positive significant effect between tutorials and acquisition of technical skills. This finding is supported by the cognitive learning theory which gives a structure that promotes understanding, making inferences and change in human behaviour. Thus, through tutorials, the interface between the trainers and trainees of mechanical engineering should create a session for reinforcement by encouraging students engineering contributions and reasoning. This will precipitate adequate acquisition of engineering technical skills thus promoting learning and behaviour change. This implies that the learning environment shouldn’t be void of a strong teacher presence within the dialectical environment to promote argument and discussion within the principles and practices of mechanical engineering. This will have the capacity to invoke intellectual curiosity among students.

Tutorials, therefore, can create an interface between the trainers and trainees that encourages students' reasoning and contribution that precipitates the adequate acquisition of engineering technical skills thus promoting learning and behaviour change. For this to be successful, the learning environment should have a strong teacher presence within the dialectical environment to promote argument and discussion within the principles and practices of mechanical engineering.

Tutorials, on the other hand, are not without limitations for example because of large classes, it is very hard for the teacher to attend to the needs of each student and the teacher is subject to becoming biased by not showing equal attention to the learners.

5.2.3 Effect of problem-based learning on the acquisition of technical skills

From table 4.29, problem-based learning had a positive significant effect on the acquisition of technical skills by mechanical engineering students F (1, 207) = 124.191 $p<0.01$. Also from table 4.28, the coefficient of determination (R^2 = 0 .375), indicated that the model explained that problem-based learning accounted for 37.5 % of the total variation in the acquisition of technical skills of mechanical engineering trainees. The unstandardized regression coefficient for problem-based learning (β= 0.354), implied that 1 unit increase in problem-based learning results in a 0.354-unit increase in the acquisition of technical skills amongst mechanical engineering trainees. A study done by Orhan & Ruhan, (2007), about the effects of PBL in Science Education on learners' academic achievement, gave a Cronbach (α = 0.89) It was found that PBL had positively affected both attitude and academic achievements. The PBL learning model also influenced the learners' achievement positively. In problem-based learning, the knowledge acquisition process depends on the learner rather than the trainer. Results are best achieved by encouraging trainees to work together in groups while trying to solve problems and think critically. The findings are supported by Baharom and Palaniandy (2013), Ibrahim et al., (2018) and Al-Drees et al., (2015) who found a positive link between problem-based learning and acquisition of skills however their studies were not conducted in national polytechnics. This finding subscribes to both cognitive learning theory and constructivism theory. The evaluation of the trainee's acuity of solutions resonates with their extent of acquisition of technical skills in mechanical engineering. This abdicates the chalk and talk and talk phenomena to students taking responsibility for their learning from the beginning of the project until the end. In problem-based learning, the core knowledge discovery process lies almost entirely in the hands of the learner rather than the teacher. Thus, trainers in national polytechnics should potentiate their problem-based learning strategies by encouraging trainees to work in groups to solve mechanical engineering-oriented problems to develop critical thinking and problem-solving skills in that field.

5.2.4 Effect of project-based learning on the acquisition of technical skills

Project-based learning had a positive significant effect on the acquisition of technical skills among mechanical engineering students in national polytechnics in western Kenya region F (1, 207) = 80.275, p <0.01 according to table 32. Also from table 31, the proportion of variance (R^2 = 0.279) means that project-based learning accounted for 27.9 % of the total variation in the acquisition of technical skills of mechanical engineering trainees. The unstandardized regression coefficient of 0.433 for project-based learning implied that a 1 unit increase in project-based learning results in a 0.433 unit increase in the acquisition of technical skills by mechanical engineering trainees. In project-based learning, students acquired hands-on and cognitive skills. Trainees acquired skills by discovering, innovating, and performing. This research compares very well with the findings of Mills, (2002) and Podges et al., (2014), who said that learners who used Project-based learning were found to be more responsible and successful in their studies. During the same study, the learners using PBL were more curious, more reflective and more practical oriented. However, in adopting project-based learning trainees should be encouraged to be innovative in designing and implementing solutions for mechanical engineering technology problems as a means of reinforcing and utilizing their acquired technical skills. The study findings are supported by Mioduser and Nadav (2018), Mohsen et al., (2013) and Anabela et al., (2017) who also found a positive and significant link between project-based learning and acquisition of technical skills. These findings are premised on the constructivism theory and cognitive learning theory. This means by students have control over their projects they will work on them from the beginning until the end product. Students learn by discovering, innovating, and performing, this has the capacity of equipping them with technical skills in mechanical engineering. From this research, national polytechnics need to organize and strengthen their pedagogical approaches and strategies which promote project-based learning. This implies that the teaching process in mechanical engineering should be organized through constructive, creative and generative activities capable of inculcating the technical skills amongst mechanical engineering students. However, in adopting project-based learning, trainees should be encouraged to be innovative in designing and implementing solutions for mechanical engineering technology problems as a means of reinforcing and utilizing their acquired technical skills.

5.2.5 Effect of workshop training on the acquisition of technical skills

It can be inferred from table 4.35 that training through workshops also had a positive significant effect on the acquisition of technical skills among mechanical engineering trainees in national polytechnics in the western Kenya region$(F = 70.408; P < 0.01)$. Table 4.34 gave the coefficient of determination R^2 = 0.254 meant that 25.4% of the total variation in the acquisition of technical skills amongst mechanical engineering trainees was attributable to workshop training. The unstandardized regression coefficient was 0.492 for the workshop training method, implying that 1 unit increase in the workshop training method caused 0.492 units to increase in the acquisition of technical skills amongst mechanical engineering students. Workshop training is an interactive form of hands-on training with the capacity of providing students with exposure to the latest technologies and therefore helping the students to acquire technical skills. These findings are in line with the findings of Faas and Daniel (2013); Segun et al., (2014); Sanjeev et al., (2017) who found a positive influence of workshop training on the acquisition of technical skills. These findings are supported by constructivism theory and cognitive learning theory. It can therefore be inferred that workshop training as a form of hands-on training has the capacity of providing students with exposure to the latest technologies and helping students acquire technical skills. Workshop training should be designed in a way that engenders trainees' confidence in their mechanical engineering skills.

5.2.6 The effect of multiple teaching methods on the acquisition of technical skills in mechanical engineering

Collectively, all the five teaching methods namely; work-based learning, tutorials, problem-based learning, project-based learning and workshop training had a positive significant effect on the acquisition of technical skills among mechanical engineering trainees ($F=82.653$; $p<0.001$). The effect of the five teaching methods is illustrated in table 4.38. This implies that national polytechnics should embrace an array of teaching methods and proactively formulate policies and resources which support the teaching methods understudy, and then the acquisition of technical skills among mechanical engineering students is likely to improve. The coefficient of determination $R^2 = 0.671$ implied that the model explained 67.1% of the variation in all the five teaching methods combined. This correlates very well with the findings of Isa et. al (2020) that confirmed learner-centred teaching methods have a great influence on academic performance. The methods under study were those methods that engage learners and were interactive. This is supported by Udofia et al., (2012); Delaney and Nagle (2019) who found a significant relationship between teaching methods and students’ skill acquisition. According to Delaney and Nagle (2019), graduates are expected to be more productive rather than solve technical problems as they were taught at engineering school. Problem-based being one of the active learning processes; it had to be incorporated into mechanical engineering students at Technological University Dublin. This made the learners more competent and prepared for their future careers in mechanical engineering. Consequently, TVET teachers are therefore expected to apply multiple methods of instruction especially those that engage learners actively to give students real-world practical engineering skills for them to be relevant when they complete their studies at the national polytechnics and seek employment. This argument and findings are premised on the constructivism theory and cognitive learning theory.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

Appropriate teaching methods are key to enhancing the acquisition of technical skills in mechanical engineering in national polytechnics. Results from the study showed that combining all the five teaching methods namely; work-based learning, tutorials, problem-based learning, project-based learning and workshop training had the highest positive impact on the acquisition of technical skills of mechanical engineering trainees in national polytechnics compared to individual use of these methods.

Based on the unstandardized coefficients, project-based learning was the greatest contributor to the acquisition of technical skills in mechanical engineering followed by work-based learning, workshop training, problem-based learning and tutorials respectively. This implies that individual teaching methods have different strengths in the acquisition of technical skills of mechanical engineering students. This implies that the TVET institutions should synergistically bundle the teaching methods to secure the maximal acquisition of technical skills in mechanical engineering.

This research concludes that teaching methods are crucial in boosting the acquisition of technical skills in mechanical engineering in national polytechnics. Therefore, TVET instructors need to use an array of correct methods of instruction to maximize the acquisition of practical skills for marketability and employability of the trainees after their learning program.

The study explored the effect of teaching methods such as work-based learning, tutorials, problem-based learning, project-based learning and workshop training on the acquisition of technical skills in mechanical engineering in national polytechnics. The study concludes that teaching methods are key to enhancing the acquisition of technical skills in mechanical engineering in national polytechnics. Therefore, TVET teachers need to apply appropriate methods of instruction so that the learners may gain practical and relevant soft skills for them to be employable when they complete their learning program. This argument and findings are premised on the constructivism theory and cognitive learning theory.

Based on this research, all the teaching methods studied should not be relegated to the periphery but should be an embodiment of curriculum delivery for ensuring the acquisition of technical skills. This is supported by the fact that all these teaching methods understudy jointly and independently affected to some degree, the acquisition of technical skills in mechanical engineering trainees. It is therefore important that national polytechnics and stakeholders should strive to promote and improve these teaching methods by providing the much-needed resources.

6.1 Recommendations

This chapter has presented recommendations on the assessment of the effect of teaching methods on the acquisition of technical skills for mechanical engineering trainees in 3 national polytechnics (Kisii, Kisumu and Sigalagala) in the western Kenyan region. Collectively all the five teaching methods namely; work-based learning, tutorials, problem-based learning, project-based learning and workshop training had a positive significant effect on the acquisition of technical skills among mechanical engineering trainees. Project-based learning was the greatest contributor to the acquisition of technical skills in mechanical engineering followed by work-based learning, workshop training, problem-based learning and tutorials respectively.

From the study findings, the following recommendations were made;

- TVET teachers need to make significant contributions towards developing learners who possess employable skills, essential thinking skills and practical skills that are required by the job market by the time the learners complete their study programs. Therefore, the study has recommended that national polytechnics should embrace an array of teaching methods and proactively formulate policies and provide resources which support the teaching methods understudy to improve the acquisition of technical skills among mechanical engineering students.
- In adopting project-based learning trainees should be encouraged to be innovative in designing and implementing solutions for mechanical engineering technology problems as a means of reinforcing and utilizing their acquired technical skills. In line with this view, it remains inordinately necessary for national polytechnics to analyse and strengthen their pedagogical approaches and strategies which promote project-based learning.
- Workshops training should be designed in a way that builds the confidence of the trainee in their mechanical engineering skills. There is a need to expand workshop rooms, spaces and equipment. Teachers need to continuously be retrained since national polytechnics in Kenya continue to receive new equipment in the laboratories and workshops. It is hoped that the effect of this teaching method on the students' technical skills acquisition may improve.

- Through tutorials, the interface between the trainers and trainees of mechanical engineering should create a session for reinforcement by encouraging students engineering contributions and reasoning. Trainers in national polytechnics should also encourage problem-based learning strategies by encouraging trainees to work in groups to solve mechanical engineering problems.
- There is a need to have a plan for teachers of mechanical engineering to be stationed in the industry so that their competencies in terms of problem-solving, practical orientation and collaboration with the industry can be enhanced. In-service training that is flexible and adaptable is also recommended.
- Work-based learning should also be structured around activities that enhance the acquisition of technical skills in mechanical engineering. Teachers of mechanical engineering at TVET institutions should be responsible while undertaking industrial supervision of learners when they are stationed at work stations. From the economic point of view, learning that takes place at the employers' premises should be much cheaper since learning utilizes plant and equipment at the employers' premises. In respect of this, learning will always match the current industrial practices which are relevant to the employers' needs and skills.

6.2 Suggestions for further research

The study focused on five teaching methods in three national polytechnics. To conclusively determine the best methods for instruction in mechanical engineering, there is a need to expand the scope of the study to include several other TVET institutions as well as exhaustively look at all methods used. There is also a need to explore some of the challenges that hamper the use of some of the methods including the influence of policy and infrastructure challenges on curriculum and its implementation in TVET institutions across the country. This implies that individual teaching methods have different strengths in the acquisition of technical skills of mechanical engineering students. However, to conclusively determine the best methods for instruction in mechanical engineering, there is a need to expand the scope of the study to include several other TVETs as well as exhaustively look at all methods used besides their challenges.

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APPENDICES

APPENDIX I: QUESTIONNAIRE FOR THE TRAINERS

This study focuses on the perceptions of mechanical engineering students and teachers towards teaching methods for the acquisition of technical skills. The respondents in the questions outlined below are not required to fill in their identification details such as names or personal numbers. All responses to the items in this questionnaire are anonymous; the respondents are free to withdraw of their own free will. This questionnaire is for academic purposes only. You are encouraged to respond to the questions to the best of your knowledge.

Kindly put a tick (✔) against the correct choice.

SECTION A

1. Age bracket

Less or equal to 30 years	[ ]	31 to 40 years	[ ]
41 to 50 years	[ ]	Over 50 years	[ ]

2. Gender

Male	[ ]	Female	[ ]

3. Highest level of education?

Diploma	[ ]	Higher Diploma	[ ]
Bachelors’	[ ]	Masters	[ ]
PhD	[ ]		

4. What is the duration you have taught in TVET institutions?

Less or equal to 5 years	[ ]	6 to 10 years	[ ]
11 to 15 years	[ ]	16 to 20 years	[ ]
Above 20 years	[ ]		

SECTION B: INSTRUCTIONS

Please show the degree of agreement or disagreement with the items outlined in this questionnaire by placing a tick appropriately on the 5-Point Likert scale: In Parts **I, II** and **III**.

5 = Very Great Extent (VGE), 4 = Great Extent (GE), 3 = Moderate Extent (ME), 2 = Small Extent (SE), 1 = Very Small Extent (VSE).

PART I: METHODS OF TEACHING

This part has parts 1a, b, c and d

PART I a: WORK-BASED LEARNING

Kindly, mark with a (✔) to show the extent to which you agree with the following statements on the work-based learning method

	WORK BASED LEARNING	5 VGE	4 GE	3 ME	2 SE	1 VSE
1	The projects and assignments undertaken during work-based learning are challenging for me.					
2	Academic and occupational circulars are kept up-to-date by regularly integrating school and industry activities.					
3	Work-based learning prepares the student to locate permanent job opportunities					
4	Work-based learning provides the student with authentic experiences					
5	Work-based learning method enhances learning quality					
6	Enables trainees to familiarize themselves with the work environment and industry terminologies and business protocols.					

PART I b: TUTORIALS

Kindly, mark with a (✔) to show the extent to which you agree with the following statements on the tutorials

TUTORIALS	5 VGE	4 GE	3 ME	2 SE	1 VSE
1 In social interaction corrective procedures are intensified to enhance mastery of subject matter					
2 Repeated tests are conducted to evaluate the measure students' mastery of the subject matter.					
3 Through social interaction, the student's willingness to question what is not clear has increased					
4 Learning has been student centred					
5 The student's private interaction with the learning materials has increased their intellectual curiosity					

PART I c: PROBLEM-BASED LEARNING

Kindly, mark with a (✔) to show the extent to which you agree with the following statements on problem-based learning

PROBLEM-BASED LEARNING	5 VGE	4 GE	3 ME	2 SE	1 VSE
1 Learners are actively engaged during the teaching process.					
2 Problems during the teaching process are in line with the student's prior knowledge					
3 The group sizes are appropriate to stimulate learning					
4 Trainers stimulate the students to apply knowledge in other situations					
5 The trainers are motivated to fulfil their role					

PART I c: PROJECT-BASED LEARNING

Kindly, mark with a (✔) to show the extent to which you agree with the following statements on project-based learning

PROJECT-BASED LEARNING	5 VGE	4 GE	3 ME	2 SE	1 VSE
1 The students try their best even when it is a difficult task.					
2 The students cannot follow complex instructions unless someone shows them how to do it.					
3 The students value working with other students.					
4 The students can gather information from different sources.					
5 The students can plan out projects from start to finish					
6 When the students work hard on something it shows in the results.					

PART I e: WORKSHOP TRAINING

Kindly, mark with a (✔) to show the extent to which you agree with the following statements about workshop training

WORKSHOP TRAINING	5 VGE	4 GE	3 ME	2 SE	1 VSE
1 I am effective in illustrating some method or technique of doing a job.					
2 The teacher has the opportunity to run through the demonstration before the students enter the workshop.					
3 The teachers continually correct and advise the trainee throughout the whole of the work-shop practice period.					
4 The teachers maintain contact with all students without distracting.					

5	There is reduced spoilt work after reasonable practice and tuition					

PART I I: ACQUISITION OF TECHNICAL SKILLS

Kindly, mark with a (✔) to show the extent to which you agree with the following statements on the acquisition of technical skills

ACQUISITION OF TECHNICAL SKILLS		5 VGE	4 GE	3 ME	2 SE	1 VSE
1	Remembering or retrieving previously learned material					
2	The ability to use learned material, or to implement the material in new and concrete situations					
3	distinguish the parts of material into its components so that its organizational structure may be better understood					
4	Ability to perform engineering tasks based on the acquired Knowledge					
5	The trainers can design materials and outputs based on changing technology					
6	Learners can display their technical skills					

APPENDIX II: Questionnaire for the trainees

This study focuses on the perceptions of mechanical engineering trainers/teachers and students towards teaching methods for the acquisition of technical skills. The respondents in the questions outlined below are not required to fill in their identification details such as names or personal numbers. All responses to the items in this questionnaire are anonymous; the respondents are free to withdraw at their own free will. This questionnaire is for academic purposes only. You are encouraged to respond to the questions to the best of your knowledge.

QUESTIONNAIRE NUMBER

Kindly put a tick (✔) against the correct choice.

SECTION A

1. Age bracket

Less or equal to 30 years	[ ]	31 to 40 years	[ ]
41 to 50 years	[ ]	Above 50 years	[ ]

2. Gender

Male	[ ]	Female	[ ]

SECTION B: INSTRUCTIONS

Please show the degree of agreement or disagreement with the items outlined in this questionnaire by placing a tick (✔) appropriately on the 5-Point Likert scale: In Parts I, II and III.

5 = Very Great Extent (VGE), 4 = Great Extent (GE), 3 = Moderate Extent (ME), 2 = Small Extent (SE), 1 = Very Small Extent (VSE).

PART I: METHODS OF TEACHING

This part has parts 1a, b, c and d

PART I a: WORK-BASED LEARNING

Kindly, mark with a (✔) to show the extent to which you agree with the following statements on the work-based learning method as a mechanical engineering student

WORK-BASED LEARNING		5	4	3	2	1
		VGE	**GE**	**ME**	**SE**	**VSE**
1	The projects and assignments undertaken during work-based learning are challenging.					
2	School and industry activities are updated regularly.					
3	Work-based learning prepares the student to locate permanent job opportunities					
4	Work-based learning provides the student with authentic experiences					
5	Quality of learning is enhanced by work-based learning					
6	Exposes students to the terminology of work environment and business and industry protocol.					

PART I b: LEARNING THROUGH TUTORIALS

Kindly, mark with a (✔) to show the extent to which you agree with the following statements about tutorials as a method of learning.

TUTORIALS		5	4	3	2	1
		VGE	GE	ME	SE	VSE
1	I have the freedom to question what is not clear					
2	Learning is student-centred					
3	My curiosity to interact with learning materials increases					
4	The student peers are encouraged to expose their colleagues to concepts they are not able to understand					
5	The students are encouraged to study privately on their own					

PART I c: PROBLEM-BASED LEARNING

Kindly, mark with a (✔) to show the extent to which you agree with the following statements on problem-based learning.

PROBLEM-BASED LEARNING		5	4	3	2	1
		VGE	GE	ME	SE	VSE
1	Our trainers are motivated to fulfil their role of teaching					
2	Students take a key role in diagnosing learning needs.					
3	Students can identify learning objectives.					
4	Real-world problems are related to the mechanical engineering world					
5	Enhances interest in the subject matter					

PART I c: PROJECT-BASED LEARNING

Kindly, mark with a (✔) to show the extent to which you agree with the following statements on project-based learning

PROJECT-BASED LEARNING		5	4	3	2	1
		VGE	GE	ME	SE	VSE
1	I can make valuable contributions to a project					
2	I view challenging problems as tasks to be mastered					
3	I care about my project					
4	I can learn from my classmates					
5	I believe that difficult tasks are beyond my capabilities					

6	I keep trying when things get hard					
7	I can try harder when the teacher gives me encouragement					
8	I know what steps to take to solve a problem					

PART I e: WORKSHOP TRAINING

Kindly, mark with a (✔) to show the extent to which you agree with the following statements on workshop training

	WORKSHOP TRAINING	5	4	3	2	1
		VGE	GE	ME	SE	VSE
1	All students' work is completed and tested within a given period					
2	Workshop practice scheduled time is strictly followed					
3	Students take workshop practice assignments seriously					
4	Adequate resources are provided for workshop practice					
5	Workshop classes are not overloaded					
6	There is adequate guidance on the design project					
7	Sheet metal exercises are adequately practised					
8	Various tools are demonstrated and trainers practice how to use them					
9	Trainers use all tools needed for fabrication which were demonstrated during the training sessions.					
10	Scrap materials are reused effectively during workshop practicals					
11	Theoretical as well as practical skills occur at					

	the same time as workshop training takes place					
12	Instead of overburdening reports trainers only present finished products that satisfy the objectives/goals of the project design.					

PART I I: ACQUISITION OF TECHNICAL SKILLS

Kindly, mark with a (✔) to show the extent to which you agree with the following statements about the acquisition of technical skills by mechanical engineering students

ACQUISITION OF TECHNICAL SKILLS		5	4	3	2	1
		VGE	GE	ME	SE	VSE
1	Learners can display their technical skills					
2	learning package provides updated information to meet modern industrial needs					
3	The learning method adds value to the engineering education courses					
4	The learning package has applicable information to meet both the TVE and the industrial objectives					
5	The intellectual curiosity of the learners has increased					
6	The trainer can use acquired knowledge to design an experiment					

APPENDIX III: Krejcie and Morgan table

N	*S*	*N*	*S*	*N*	*S*
10	10	220	140	1200	291
15	14	230	144	1300	297
20	19	240	148	1400	302
25	24	250	152	1500	306
30	28	260	155	1600	310
35	32	270	159	1700	313
40	36	280	162	1800	317
45	40	290	165	1900	320
50	44	300	169	2000	322
55	48	320	175	2200	327
60	52	340	181	2400	331
65	56	360	186	2600	335
70	59	380	191	2800	338
75	63	400	196	3000	341
80	66	420	201	3500	346
85	70	440	205	4000	351
90	73	460	210	4500	354
95	76	480	214	5000	357
100	80	500	217	6000	361
110	86	550	226	7000	364
120	92	600	234	8000	367
130	97	650	242	9000	368
140	103	700	248	10000	370
150	108	750	254	15000	375
160	113	800	260	20000	377
170	118	850	265	30000	379
180	123	900	269	40000	380
190	127	950	274	50000	381
200	132	1000	278	75000	382
210	136	1100	285	1000000	384

Note.—*N* is population size. *S* is sample size.

Source: Krejcie & Morgan, 1970

APPENDIX IV: RESEARCH AUTHORIZATION PERMIT – NACOSTI

CONDITIONS

1. You must report to the County Commissioner and the County Education Officer of the area before embarking on your research. Failure to do that may lead to the cancellation of your permit
2. Government Officers will not be interviewed without prior appointment.
3. No questionnaire will be used unless it has been approved.
4. Excavation, filming and collection of biological specimens are subject to further permission from the relevant Government Ministries.
5. You are required to submit at least two(2) hard copies and one(1) soft copy of your final report.
6. The Government of Kenya reserves the right to modify the conditions of this permit including its cancellation without notice

REPUBLIC OF KENYA

NACOSTI

National Commission for Science, Technology and Innovation

RESEARCH CLEARANCE PERMIT

Serial No. A 5927

CONDITIONS: see back page

THIS IS TO CERTIFY THAT:
MR. WYCLIFFE LUMUMBA MIGIRO
of UNIVERSITY OF ELDORET, 1893-40200 Kisii,has been permitted to conduct research in *Kisii , Nairobi, Uasin-Gishu Counties*

on the topic: *EFFECTIVE TEACHING METHODS IN MECHANICAL ENGINEERING AT TECHNICAL TRAINING INSTITUTES IN KENYA*

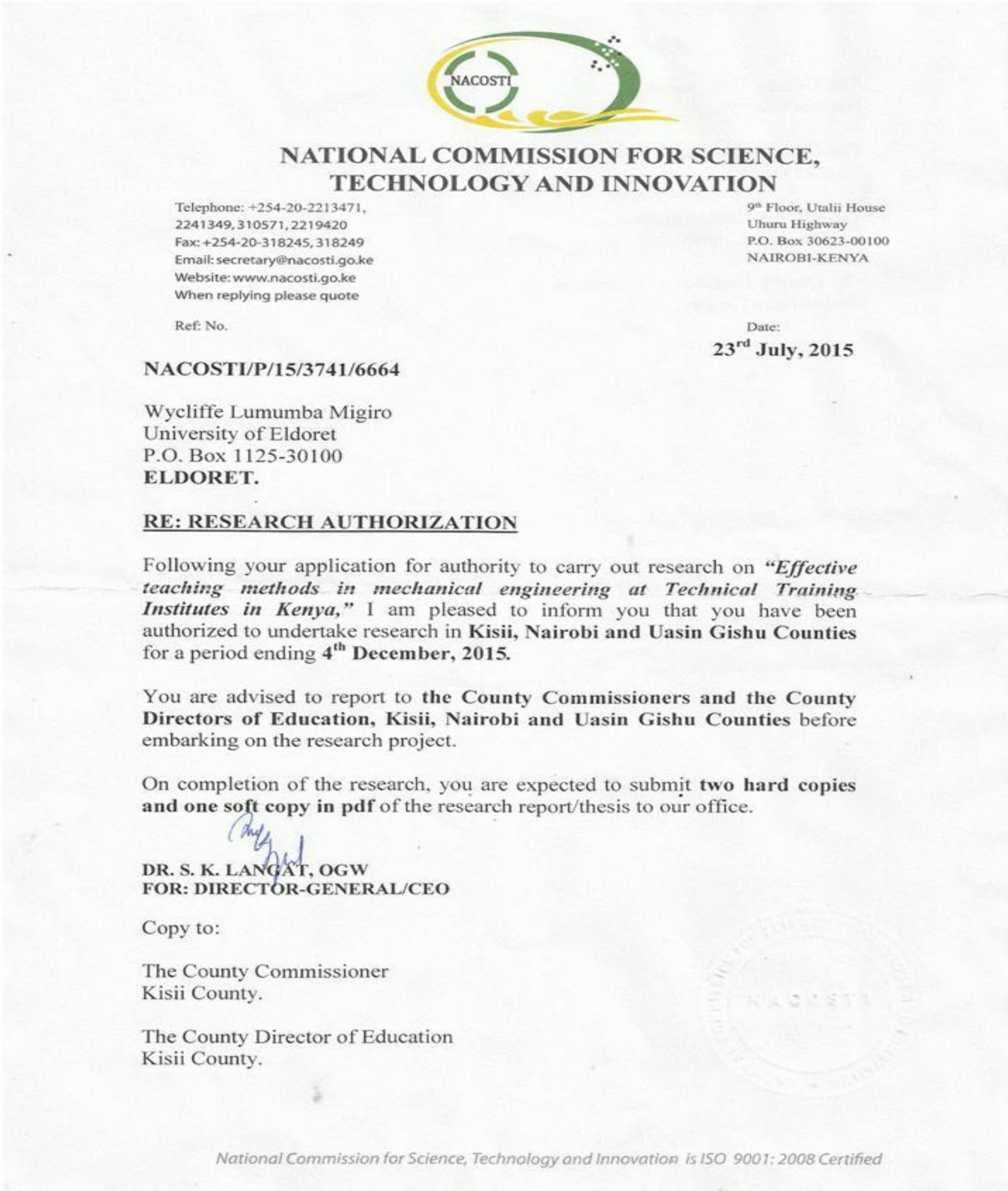
for the period ending:
4th December,2015

Permit No : NACOSTI/P/15/3741/6664
Date Of Issue : 23rd July,2015
Fee Recieved :Ksh 1,000

Applicant's Signature

Director General
National Commission for Science, Technology & Innovation

APPENDIX V: RESEARCH AUTHORIZATION LETTER TO COLLECT DATA – NACOSTI



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Website: www.nacosti.go.ke
When replying please quote

9th Floor, Utalii House
Uhuru Highway
P.O. Box 30623-00100
NAIROBI-KENYA

Ref: No.

NACOSTI/P/15/3741/6664

Date:
23rd July, 2015

Wycliffe Lumumba Migiro
University of Eldoret
P.O. Box 1125-30100
ELDORET.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***"Effective teaching methods in mechanical engineering at Technical Training Institutes in Kenya,"*** I am pleased to inform you that you have been authorized to undertake research in **Kisii, Nairobi and Uasin Gishu Counties** for a period ending **4th December, 2015.**

You are advised to report to **the County Commissioners and the County Directors of Education, Kisii, Nairobi and Uasin Gishu Counties** before embarking on the research project.

On completion of the research, you are expected to submit **two hard copies and one soft copy in pdf** of the research report/thesis to our office.

DR. S. K. LANGAT, OGW
FOR: DIRECTOR-GENERAL/CEO

Copy to:

The County Commissioner
Kisii County.

The County Director of Education
Kisii County.

National Commission for Science, Technology and Innovation is ISO 9001: 2008 Certified

APPENDIX VI: SIMILARITY REPORT

Turnitin Originality Report

THE EFFECT OFSELECTED TEACHING METHODS ON ACQUISITION OF TECHNICAL SKILLS BY MECHANICAL ENGINEERING TECHNICIAN TRAINEES A CASE OF NATIONAL POLYTECHNICS IN THE WESTERN REGION OF KENYA by Wycliffe Lumumba

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