PROBLEM-BASED LEARNING FOR TECHNICAL TEACHER TRAINING IN WOODWORK AT THE MALAWI POLYTECHNIC

MASTER OF TECHNICAL AND VOCATIONAL EDUCATION
THESIS

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University of Malawi

The Polytechnic

July, 2017

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By

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DECLARATION

I, Emmanuel Alinafe Molande declare that this thesis is my own original work. Where other sources of information have been used, they have been acknowledged. I hereby certify that this work has not been submitted before in part or full for any other degree or examination.

SIGNATURE :

DATE :

CERTIFICATE OF APPROVAL

We, the undersigned, certify that we have read and hereby recommend for acceptance by the University of Malawi a thesis entitled *Problem-Based Learning for Technical Teacher Training in Woodwork at The Malawi Polytechnic*.

Dean - Postgraduate : _____

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Co-Supervisor : _____

Signature : _____

Date : _____

Head of Department : _____

Signature : _____

Date : _____

DEDICATION

This thesis is dedicated to my mother, Denizia Molande. You are wonderful mum.

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Many people played a role in this study and the struggle could have been real without them.

I would like to express my sincere appreciation to my supervisors, Associate Professor Vanwyk Khobidi Chikasanda and Mrs Doris Mtemang'ombe for the support rendered during the study. Your guidance, clear expectations and encouragement offered are what made this work come this far.

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ABSTRACT.

The paper reports on a study that investigated the effectiveness of the use of Problem-Based Learning (PBL) on students' performance in Woodwork at a Malawian technical teacher training college, specifically, The Malawi Polytechnic. It also sought to investigate students' attitude towards PBL. The rationale for the study was grounded on the fact that PBL models are constructivist in nature, hence they promote cognitive development and active learning which in turn enhances performance.

The study employed the positivists approach as the data to be collected were quantitative in nature and it involved generating statistical significance of parameters under test. The study employed a pre- and post-test control group experimental design in which an intervention, instruction using the PBL approach, was implemented on the experimental group whilst the control group learnt through the traditional approach. A class of 62 students participated in the study. The class was divided into two groups, with each group comprising 31 students to form the experimental and control group. Data for the study was collected using achievement tests and questionnaires. The scores for the pre- and post-test assessment for the two groups were compared and analysed using an independent samples t-test.

Results showed that the students' mean scores from the pre-test were not significantly different ($t = -1.06$, $d = -3.00$, $p = 0.292$) at 5% significance level. Analysis of the post-test assessment scores showed a significant difference in the results ($t = 3.81$, $d = 11$, $p = 0.000$). The results of the analysis of change in scores indicated that there was an increase in the scores from the pre-test to the post-test for both the experimental and control groups. However, the increase in the assessment scores was significantly greater for the students in the PBL approach group (Mean =22.94, standard error =2.02) than the students in the traditional approach group (Mean=8.94, standard error = 2.41). Overall, the students expressed their desire to learn through PBL as they considered it effective.

The students that learnt using PBL were better in knowledge acquisition, interpretation and application. The PBL students also outperformed the traditional students in analytical skills. This showed that PBL is an effective approach to teaching and learning of Woodwork.

Therefore, the study recommends that lecturers should engage PBL in technical teacher training in Woodwork and other technology related studies.

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ACRONYMS

3C3R	:	Content, context and connection and researching, reasoning and reflecting
CBET	:	Competence Based Education and Training
CEB	:	Cambridge Examination Board
CDSS	:	Community Day Secondary School
DBL	:	Design Based Learning
GoM	:	Government of Malawi
IBL	:	Inquiry Based Learning
LEB	:	London Examination Board
MEQs	:	Modified essay questions
MoEST	:	Ministry of Education, Science and Technology
MoL	:	Ministry of Labour
PBL	:	Problem-Based Learning
TEVET	:	Technical, Entrepreneurial and Vocational Education and Training
TEVETA	:	Technical, Entrepreneurial and Vocational Education and Training Authority
TVET	:	Technical and Vocational Education and Training
USAID	:	United States Agency for International Development
UNESCO	:	United Nations Educational, Scientific and Cultural Organisation

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CHAPTER ONE

INTRODUCTION

1.1 Chapter overview

Chapter one deals with the introduction to the study of the effectiveness of Problem-Based Learning (PBL) in enhancing students' understanding of Woodwork concepts at The Malawi Polytechnic. It documents the background of the study, pedagogical reforms in education and technical teacher training models. It also covers statement of the problem, purpose of the study, research objectives and significance of the study.

1.2 Background of the study

Many countries are faced with different challenges that include poverty (Ary, Jacobs, Razavieh, & Serensen, 2006; Cohen, 2006; Sampson & Morenoff, 2006). As such, education must be developed in such a way that it takes into account societal changes (Sahlberd, 2006). Sahlberd (2006) observes that aligning education to the changing needs of the society improves the relevance of education to the nation. Research has shown that education is one of the most effective investments to improving the economic status of many nations and helping the people to improve their livelihood (Blewitt, 2004). Economists have also acknowledged the importance of education (Barrett, Duggan, Lowe, Nikel, & Ukpo, 2006; Murphy, 2012). Thus, the role an educated populace plays in developing countries is evidence to these claims about the link between education and economy. However, for education to directly impact on its citizens, it must be relevant (Murphy, 2012).

Education in Malawi is governed by the Education Act of 2013 (GoM, 2013). The Education Act aims at developing high quality, affordable and efficient system of education which fits together with the available resources of the country and is also in line with the advancement of the political, socio-economic and technological development of the country. Based on the National Educational Sector Plan - 2008 to 2017 (MoEST, 2008), the vision of Malawi is to use education as a tool for empowering the industry and improving the socio-economic status of the country. At the same time, education is viewed as a tool for empowering the voiceless and the marginalised (MoEST, 2008). The general objective of education remains to equip individuals with skills that may lead to self-reliance, self-employment and entrepreneurship. This means that if Malawi is to

develop, there is need for a shift in policy that must favour education for blue collar jobs rather than education for white collar jobs hence the need to promote the provision of technical and vocational education. Currently, Malawi offers Technical and Vocational Education and Training (TVET) at tertiary level through technical colleges. Malawi has four public technical colleges namely; Nasawa, Salima, Soche and Lilongwe technical colleges and five privately owned technical colleges namely; Comboni, Mzuzu, Namitete, Stephanos and SOS Children's Village. Currently, in a bid to boost technical and vocational training, the Malawi Government through the Ministry of Labour is rolling out community technical colleges (MoL, 2014). So far, 12 colleges have been opened. The Technical, Entrepreneurial and Vocational Education and Training (TEVET) was established in 1999 to promote provision of TVET in the technical colleges (TEVETA, 1998).

Technical subjects are also offered at secondary education level in Malawi. However, there are only 12 public technical secondary school out of 1094 government secondary schools that offer these technical subjects. Unfortunately, since the establishment of these technical subjects in the 12 secondary schools, there has been no expansion drive. Worse still, the few secondary schools that offer these technical subjects are not operating at full capacity due to lack of resources (MoEST, 2008). This is very unhealthy for a country grappling with high unemployment rate. This means that Malawi's secondary education curriculum still remains a path to train people who are not self-reliant. At primary school level, there are only two model primary schools that are offering technical subjects.

Therefore, there is more that the country could do to promote technology education. For instance, the number of technical colleges and secondary schools that offer technical and vocational education could have been increased to widen access (TEVETA, 1998). In addition, the TVET is supposed to have been well marketed to change its image in the general public. Most people look at TVET as "a poor cousin to general education". The researcher also recognises that for Malawi to achieve economic growth that trickles down to its citizens, its education system must prepare the citizens to become self-reliant. If technology education is offered together with design and technology as a subject, it would enhance creativity and inventiveness (Fisher & Williams, 2004). This would in turn help Malawi to realise her dream of turning from a predominantly importing nation to a largely exporting nation. In fact, most developed nations have incorporated

Technology Education subjects in their curricula, beginning right from primary schools. Some educators have even challenged that Early Childhood Education curriculum can actually incorporate some elements that promote creativity in the children (Fisher & Williams, 2004).

The methods of teaching employed to produce the much needed impact of education on the people is the main centre of focus of this study. Over a long period of time, teaching and learning had been built around behaviourism theory in which a teacher, instructor or lecturer has been the sole source of students' learning (Klien-Collins, 2013). In this traditional method of teaching, the process has been considered as a banking method in which teachers deposit a chunk of knowledge into the empty heads of the students. Students have been exposed to Pavlov's thinking cited in (Burke, 2005) that they can be conditioned so as to show some expected behaviour. Students themselves could not take part in their own learning as teachers were considered omnipotent. Greitzer, Kuchar, and Huston (2007) assert that the behaviourist approaches to teaching are narrow focused to the observable behaviour. As such, psychologists like Jean Piaget and William Perry suggested a shift from observable behaviour to cognitive structures of individuals (Slavin, 2003; Woolfolk, 2007; Seifert & Sutton, 2009). This led to the development of approaches that focus on mental processes that are involved in the learning process. The cognitive approaches contend that knowledge consists of symbolic mental representations that include propositions and images (Slavin, 2003; Woolfolk, 2007). It is also concerned with the mechanism involved in the mental representation. However, the last two decades have seen a shift in the way people perceive learning. Early views by Pavlov and Skinner that centred on the stimulus-response approach have been replaced (Seifert & Sutton, 2009).

A number of pedagogical reforms are being conducted in the training of different professions with many stakeholders advocating for the use of learner-centred approaches. According to Freire (2000), knowledge is a product of invention and reinvention. He argued that it is developed through a continuous, restless but hopeful search of the world by human beings. He contends that there is need for the use of learner-centred methods so as to allow students to participate in the learning process. The approach demands that appropriate teaching and learning materials be provided so as to promote independent learning that leads to learning through research. As such, different countries are redesigning their education system in order to achieve sustainable development (Dube & Lubben, 2011). Wals and Kieft (2010) refer to this as education for

sustainable development aimed at addressing global challenges on poverty. According to Wodi and Dukobo (2012), education is paramount to socio-political and economic development. They acknowledge the need for special training for individuals to impart specific skills.

The Malawi Polytechnic was established in 1965 as a college that offered technical and vocational training (Gomile-Chidyaonga, 2003). It was more of a technical college inclined towards training a labour force for the industry. Later in 1967, it became a constituent college of the University of Malawi and continued to offer craft programmes at artisans level through the Board of Governors (Gomile-Chidyaonga, 2003). It, however, introduced diploma programmes that were under the University of Malawi. Since then, The Malawi Polytechnic has grown with a number of faculties that include Applied Sciences, Built Environment, Commerce, Education and Media Studies and Engineering with a total of fifteen departments (Gomile-Chidyaonga, 2003). Thus the Malawi Polytechnic is a multi-disciplinary college and this makes it possible to provide solutions to the multifaceted societal challenges. The programmes have over a long time been offered at undergraduate level. However, there has been introduction of postgraduate programmes in different disciplines (Gomile-Chidyaonga, 2003). According to its strategic plan, the vision of The Malawi Polytechnic is *'To be the Centre of Excellence in the provision of scientific and technological education and training for sustainable development'* (Polytechnic, 2009). The Malawi Polytechnic has also played a leading role in the area of research and development in different disciplines.

The Malawi Polytechnic through its Technical Education Department is mandated to train teachers for technical subjects that are taught in secondary schools and technical colleges in the country. The technical subjects include Woodwork, Metalwork, Plastics and Technical Drawing. This research, therefore, sought to study the impact of PBL in enhancing students' understanding of Woodwork concepts for students pursuing Bachelor of Science degree in Technical Education at this institution.

1.3 Statement of the problem

The world is becoming more dynamic, competitive and complicated due to the ever-changing technology (Moalosi, 1999; Mshelia, 2012). As such, the needs of the society keep on changing as well. To address these changing needs of the society, it is required that the nation produces

workers that are able to address the needs of the society. There are many teaching and learning approaches that are used in educational institutions. These include inquiry methods, expository methods, observation methods, interview methods, project methods, and learning through concept (Adeyemi, Boikhutso, & Moffat, 2003). However, many teachers mostly use teacher-centred methods, also called the banking method of teaching or chalk and talk (Adeyemi et al., 2003). Freire (2000), faults the banking method of teaching as teachers explain concepts as if the contents are unfamiliar to the real world in which the learners live. He argues that learners need to interpret concepts and knowledge according to their own understanding. According to Freire, independence of the learner in understanding of knowledge is critical to learning as it allows the learner to grow intellectually. Thus education must acknowledge the existence of cognition in the learners since they are conscious beings. Freire (2000) argues that the teacher-centred methods do not allow for critical thinking by the learners as it suppresses free thinking and liberation of the mind.

The approaches employed in training individuals may affect their performance both in school and in the world of work as the skills learnt become irrelevant to future needs of the world. The study investigates the effect of Problem-Based Learning as an instructional approach to teaching of Woodwork. Johnson (2016, p. 103) argues that, "… *PBL is a vehicle for dealing with the possible mismatch as it offers both a cognitive and a collaborative approach to solving a rich, realistic problem that 'affords free inquiry by the students"*. This means a shift from the traditional teaching methods that centred more on teachers to new practices that put the students as the centre of learning. Moalosi (1999) and Mshelia (2012) argue that teachers, instructors, tutors and lecturers should adjust their teaching methods so that the methodologies address the current needs of the society. They claim that Problem-Based Learning will reduce the challenge of reliance on problems that do not concern a particular society.

The ever changing needs of the society present teachers with the challenge in developing a work force that is up to the task of addressing the fast changing challenges of the world. As such, students need to be equipped with critical thinking skills so as to make coherent decisions in their day-to-day life to counter world challenges. As Woodwork is a practical subject, there is need for the students to actively participate in their own learning. This implies the use of teaching and learning methods that are learner-centred. The need for promoting cognition in the learners is

what has motivated the researcher to conduct a study of the effectiveness of the use of PBL in Woodwork with the aim of promoting lifelong learning essential for problem solving as the students engage in complex problems that are presented to them other than the rote memory approaches. Current trends in the education sector show an emphasis on the promotion of quality and relevance of education (Shlefer, 1998; Sallis, 2002). Above all, education must be aimed at addressing current societal challenges through the use of student-centred teaching and learning approaches. Thus students need to fully participate in the learning process, thereby acquiring necessary skills to be used in the real world.

Problem-Based Learning seems to be the most plausible approach to address these issues as most models of instructional approach are more inclined towards problem solving (Barr & Tagg, 1995; Biggs, 1999). Moreover, PBL is said to promote some important non-technical skills such as decision making, research, critical thinking, creativity and communication skills which are essential in the life of individuals (Gordon, 2012). Research shows that teachers experience some unforeseeable challenges during the first years in practice which Koetsier (1995) termed as reality shock. As such, ways must be established to create real working situations within the teacher education programmes. However, there is still minimal investments in terms of human resource capacity and equipment in Technical and Vocational Education despite the overwhelming evidence of the contribution by Technical and Vocational Education sector towards economic growth of many countries.

1.4 Purpose of the study

In this 21st Century, teachers and education experts are challenged with the task of producing individuals who must be able to take the challenges of the world head-on (Faraday, Overton, & Cooper, 2011). This means that teachers must be able to equip students with skills so that they may adapt to the fast changing environment in this world. As such, there are calls for a paradigm shift in the way teachers are trained so as to deliver in their field of work. Researchers have suggested using teaching and learning approaches that promote critical thinking and creativity as a way towards problem solving (Schmidt, Loyens, Gog, & Paas, 2007). It is in this vein that this study investigated the effect of the use of PBL in technical teacher training in Woodwork at The Malawi Polytechnic. Problem-Based Learning approach to teaching and learning promotes lifelong learning which is key to professional development in technical and vocational education

(Simone, 2014). Looking at the rate at which PBL approach is being adopted in many disciplines, there is no better time to extend its use in the teaching and learning of Woodwork at The Malawi Polytechnic; hence conducting the study to check the effectiveness of the use of PBL in enhancing performance of students in Woodwork.

Therefore, this study investigated PBL as a teaching and learning approach in Woodwork. The study discussed the relevance in the use of PBL approach to teaching and learning of woodwork and recommend on the areas that might affect the implementation of Problem-Based Learning. Mizrachi, Padilla, and Susuwele-Banda (2010) support the use of PBL when they acknowledged that learning process is most effective where the students actively participate in their learning. Thus, the use of teaching and learning methods that promote students' participation is very important and PBL is considered one of the approaches that satisfy active learning principles.

The study also examined different teacher training models that are available and are being used. The main areas of concern were the instructional strategies that are currently being used. The study further discussed PBL as a constructivist instructional model. Furthermore, the research checked if the PBL approach is consistent with the principles of instruction as outlined in the constructivist theory. The study investigated the effects of PBL on how it enhanced students thinking, thus bringing in creativity and critical thinking as a way of monitoring their own understanding of the subject matter and building a great sense of social negotiation of meaning as a step towards putting theory in problem-solving into practice (Savery & Duffy, 1995).

1.5 Research objectives

The aim of this research was to investigate the effect of PBL on students learning and understanding of Woodwork at The Malawi Polytechnic. Specifically, the study sought to:

1. Compare students' performance using the PBL and traditional approaches.
2. Assess students' perception towards the use of PBL.

1.6 Significance of the study

Problem-Based Learning has been used in different fields for a long time now. Williams, Iglesias, and Barak (2008) highlight that research on PBL in many fields has shown that PBL is built on

the belief that it encompasses the concept of teaching and learning with well-grounded assessment methods. Its impact in such fields has been measured against the other methodologies. However, according to Williams et al. (2008), little research has been done from which technology educators may source inspiration. Therefore, this paper has contributed to knowledge building on PBL in technology education by studying the effect of PBL on students' understanding of woodwork concepts at The Malawi Polytechnic. In addition, the findings of this research may influence a larger study on the use of PBL in teacher training in Malawi.

The study sought to bring to light the importance of PBL in solving real life socio-economic problems that the society faces. The study aimed at bringing a shift from studying hybrid problems that are never part of the Malawi society use of authentic problems that require solutions relevant to the socio-economic needs of the nation. The findings of the study would help teachers and students to understand the importance of the use of PBL approach to teaching and learning in promoting lifelong learning that is essential for school to work transition. The study can lay foundation for further studies on the use of PBL in technical education teacher training at The Malawi Polytechnic.

The study has brought to light how PBL provides a missing link between theory and practice when it comes to teaching of Woodwork. The use of PBL which focuses on learners as active constructors of knowledge as advocated by the constructivist theory would give the student-teachers a better understanding of the subject matter by providing them with a powerful approach that enhances characteristics of pedagogical problem solving (Simone, 2008). In the same vein, PBL enhances the use of both theory and practice (Hoffman, Hosokawa, Blake, Headrick, & Johnson, 2006; Kemp, 2011). This will enable the learners to put in practice whatever they learn in class.

The success of the use of PBL approach to teaching and learning has attracted praise from many education practitioners. Research on the effectiveness of PBL at the University of Missouri-Columbia School of Medicine (UMCSOM) shows that curricular changes that were implemented in 1997 produced improved students' performance (Hoffman et al., 2006). Thus the shift from the use of traditional approaches to the PBL approach has shown that learners get more knowledge and skills that are needed to practice in the field of work. This proves the significance of the use

of PBL, which may produce the same impact if used in technical teacher training in Woodwork. Producing technical teachers who are well trained in both knowledge and skills will translate into improved teaching and learning when they go into the field of work. According to Srinivasan, Wilkes, Stevenson, Nguyen, and Slavin (2007), PBL promotes lifelong learning through research and teamwork. It also enhances critical thinking which is essential for problem solving. This is a feature that is missing in most approaches to teaching and learning.

1.7 Chapter summary

The world today demands that the workforce that is produced to take various roles in the industry is equal to the task. Thus, there is need for change in the type of graduates we are producing with much emphasis placed on the quality of learning approaches employed in order to produce high quality graduates. The chapter discussed the importance of education to the economy of a nation. It highlighted economic views on the role of education to the development of a nation. There is a mention on the importance of promoting technology education in the country as it promotes self-reliance. It briefly discussed approaches to teaching and learning and centred more on the need to shift from the traditional teacher-centred methods to learner-centred approaches. In this respect, PBL was discussed as a learner-centred approach to teaching and learning. In support of the PBL is the constructivist theory that allows learners to participate in their learning. Previous studies have produced literature in support of PBL in other disciplines like the medical education and engineering. The study, therefore, sought to investigate the effectiveness of PBL as an approach to teaching of woodwork.

CHAPTER TWO

LITERATURE REVIEW

2.1 Chapter overview

The education system has in many countries been undergoing pedagogical reforms with the aim of preparing teachers to take up the challenges of problem solving in the classroom (Simone, 2008). This study intends to examine the impact of PBL on enhancing students' understanding of Woodwork concepts at The Malawi Polytechnic. There are many studies that have been conducted to ascertain the importance of the use of PBL in other fields. This chapter, therefore, seeks to review the findings of past studies. The review assisted in the understanding of PBL concepts and will consequently help in the framing of the study. The chapter has three majors sections; theoretical background, overview of PBL and empirical evidence. The theoretical background entails the review of theories that underpin teaching and learning methods. Specifically, it was built on the theories that support PBL approach to teaching and learning. Under the empirical evidence, the researcher discusses relevant studies that have been made concerning Problem-Based Learning. The overview discusses what PBL is all about; its nature and characteristics.

2.2 Technical education

Technical education is a programme that provides individuals with some skills to enable them to address economic and social demands in the world (Umar, 2014). Its programmes are developed in such a way that it must help the learners to acquire knowledge, skills, values and attitudes that promote self-reliance.

Technical education in Malawi is more concerned with craft and transferring of skills. Chikasanda, Otrel-Cass, and Jones (2011) argue that the technical education curriculum is still colonised with many aspects that are not Malawian in nature. This means that technical education may not be able to address the socio-economic challenges that Malawi is facing. In Africa, most concepts are British oriented with the syllabus mostly borrowing from external examining boards. For example, up to 1970, Zimbabwe was still using syllabi from some external examining boards, the most common of which were the Cambridge Examinations Board (CEB) and the London Examinations Board (LEB) (Nherera, 1990). These boards were considered to provide

pre-vocational training to students and this contributed to the growth of manual labour. With the knowledge gained, the students were expected to produce artefacts based on the problem solving and design skills they are assumed to have gained.

Provision of technical education in Malawi dates back to the 19th Century. Chikasanda et al. (2011) indicate that technical education was brought by the missionaries who were more concerned with the training of personnel to assist in construction of churches. By then, government had little interest in this field as it was more concerned with the production of graduates with clerical skills. According to Chikasanda et al. (2011), the colonial government only came in with the concepts of technical education in the 1950s as a response to attempts to curb the ever-increasing unemployment rates in the country. Woodwork, Metalwork and Technical Drawing are the most common technical subjects that are offered under technical education in Malawi (Chikasanda et al., 2011).

Woodwork is a form of education and training that is aimed at preparing students to earn a living through application of technology and design (Okwori, 2012). It provides the learner with knowledge and skills to necessitate self-employment and self-reliance. Umar (2014) and Chinonso (2014) view Woodwork as a course aimed at transmitting both theory and practical skills. Okwori (2012), however, points out that emphasis should be placed on practical aspects of Woodwork rather than the theory as it provides skills that promote self-reliance in individuals.

Nherera (1990) argues that the instructional approaches mostly employed in the teaching and learning of Woodwork have been authoritarian and not stimulating. Thus the teaching of Woodwork has been far from what has been expected. Thus, the teaching approaches in Woodwork have not been based on problem solving approaches as evidenced in the tendency by students to copy design ideas from their teachers (Nherera, 1990). It is as if the use of demonstrations sends a wrong signal to the learners that those are the only available solutions to problems at hand. Nherera (1990) blames the use of authoritarian approaches to teaching of Woodwork on examinations requirements. The emphasis on performance of students in public examinations make teachers employ approaches that they feel would ensure high performance in their opinion. Nherera (1990) contends that technical education is valueless unless design education forms most part of Woodwork learning. Thus it is important that teaching of

Woodwork must develop both mental and manual skills in students (Chinonso, 2014). Chikasanda et al. (2011) also highlight that most teachers lack conceptual understanding of the subject matter in technical education leading to challenges in the implementation of technical education curriculum. Chikasanda et al. (2011) point out the lack of research to study instruction approaches in technical education.

The choice of teaching approach is affected by the time allocated to the subject (Nherera, 1990). This means that time is a very important aspect in choosing approaches to teaching. The time factor leads teachers to be more concerned with syllabus completion other than students' understanding and transferring of skills to the point of even leaving some time for revision. Thus according to such teachers, experimentation, personal studies and other practical activities remain a luxury.

Okwori (2012) also claims that another aspect that influences teachers' choice of teaching approaches is the availability of facilities. Some studies have revealed teachers' inadequacies in the teaching of Woodwork despite high qualifications (Okwori, 2012). He argues that the objectives of technical education are not met as transferring of technical skills is not achieved. According to Nherera (1990), in Nigeria, most institutions lack teaching and learning facilities for woodwork. As a result, most teachers resort to methodologies that suit theory more than practice. He is of the view that if woodwork was properly delivered, most graduates would have been involved in businesses related to their field of specialisation. Thus lack of infrastructure for woodwork lessons is equated to barrier to indigenous technological advancement.

The impact of woodwork as a subject in our day to day lives is largely dependent on the skills that teachers have (Umar, 2014). Teaching must facilitate learning (Okwori, 2012; Chinonso, 2014). Therefore, teachers must fully interact with the environment. Students learn better if they are fully involved in the learning situations. More importantly, teachers' experiences through training and in the field is also of paramount importance to choosing the teaching approaches (Nherera, 1990).

Where teachers lack the necessary skills, it is most likely that technical education will continue to suffer unpopularity as it results in the production of unskilled labour-force that is not ready to

take up different positions in the industry. Umar (2014) claims that a study by Sara in Nigeria in 2001 showed that more than 60% of technical education teachers in tertiary education in Nigeria lack practical skills. Technical education teachers need to be well trained so that they may be able to operate equipment and use tools appropriately (Chinonso, 2014). With the ever-advancing technology and manufacturing demands, the need for skilled labour force for improved productivity is unquestionable. This remains a challenge unless professional personnel are trained to match the task.

There is a need to shift teaching of technical education from what Alade (2011) calls traditional didactic technology to approaches that are more practical to ensure transferring of skills. He encourages the use of approaches that are constructivist in nature where learners are expected to construct knowledge from their experiences. Alade (2011), however, recommends a blend of traditional approaches and PBL methods. The study claimed that the blended approaches had produced positive results in training woodwork professionals. Alade (2011) argues that this works better with a low student-teacher ratio. Studies have shown an increasing emphasis on the need to base choice of teaching and learning approaches in woodwork and other technical subjects on problem solving design (Nherera, 1990).

Technical subjects have suffered an inferiority complex. For instance, in Zimbabwe in the early days of its introduction, the technical subjects were considered to be for those individual who were academically weak (Nherera, 1990). The graduates from these courses were to take up positions that required semi-skilled labour-force in the industry. Nherera (1990) argues that technical education will continue to be inferior if teachers and authorities do not pay attention to cognitive development of the students. Therefore, the use of PBL may assist to develop the cognitive skills of the learners in so doing promoting creativity and critical thinking. It is for this reason that this research centres on PBL at The Malawi Polytechnic. The development of the cognitive skills must then enhance the development of manipulative skills in the learners.

Okwori (2012) argues that most developing nations are not advancing technologically because of their heavy reliance on imported technologies. However, if technical subjects such as woodwork were taken seriously, most of these third world nations would have developed to a great extent. Okwori (2012) and Chinonso (2014) further consider forex saving in case the technological

advancement was locally driven. They are of the view that if developing nations were able to produce their own technology in the transportation and construction sectors, the forex used to import the same would have been saved for other purposes. Many developing nations need to improve productivity so as to improve their economic status and technological advancement (Middleton, Ziderman, & Adams, 1991). They argue that the objectives of technical education are not met as transferring of technical skills is not achieved.

Middleton et al. (1991) and Okwori (2012) acknowledge that technology development has greatly contributed to the improved socio-economic status of many nations. Chinonso (2014) shares the same views that Woodwork technology education and other technical subjects have the capacity of creating employment and training others through apprenticeship.

2.3 Problem-Based Learning

The concept of Problem-Based Learning was first used in medical education in the 1960s (Newman, 2005; Schmidt et al., 2007; Williams et al., 2008; Strobel & Barneveld, 2009). Problem-Based Learning is a student-centred learning approach that intends to give the students an opportunity to blend theory and practice. This can be achieved through research and application of the learned experiences, knowledge and skills in problem solving. The approach, thus, has the power to develop professional skills that are applicable to the real world of work in the learners (Savery, 2006). Problem-Based Learning usage has over time spread in the training of other professions. According to Schmidt et al. (2007) and Williams et al. (2008), PBL makes use of problems that are carefully constructed and then given to students so that they may find a solution to that problem. In most cases, the problem contains a description of events or situations that are observable and it is to be explained using some theoretical framework. Thus to provide a solution to the problem, the students must first tentatively identify a theory that may explain the event or situation. Being novice learners with a narrow knowledge base, the students are bound to face challenges. It must be noted that these challenges are meant to be building blocks for students' learning (Schmidt et al., 2007). Problem-Based Learning assumes that there is no one solution to a problem. Thus the solutions and the process of finding them may vary from one individual or group to another. This implies that PBL helps students discover multiple skills to problem solving.

According to Schmidt et al. (2007), the students normally work in small groups that must meet at scheduled times with breaks in between to allow for individual learning on issues concerning the problem at hand. In the subsequent meeting after individual learning, the students share their views to the problem. Varying views must be taken on board and critically reflected upon. These meetings provide an opportunity for self-evaluation on their understanding of the problem. In all this process, the teacher must guide the students. The main task is to ensure that they: stimulate discussion amongst students in the groups; make sure that all members of the group actively contribute in the discussions; give the students expert knowledge where necessary; and assess progress made by the students.

Newman (2005) and Schmidt et al. (2007) raise an important issue about PBL when they argue that it involves cognitive architecture. Sweller (2008) and Langley, Laird, and Rodgers (2009) describe cognitive architecture as hypothetical structures of the mind that explain how the mind yield intelligent behaviour under different and complex conditions. In this respect, there are two processes that play an important role to PBL; a recall of prior knowledge and application of that prior knowledge to current problems. With this process, the problem discussion initiates the activation of the prior knowledge in the students and the prior knowledge helps the students in understanding the problems. In essence, Newman (2005, p. 12) summarises this argument by saying that PBL promotes "emotional, intellectual, and practical independency in students." Problem-Based Learning is viewed to be important in encouraging learners to discover learning techniques and be able to use the same. The ability to discover the learning techniques is the basis for the attainment of critical thinking and problem solving skills. This supports the use of PBL in many disciplines.

Problem-Based Learning promotes learner's conceptual understanding of the subject matter and nurtures the learners' ability to reason and communicate in the area of interest. The role of teachers in the PBL approach to teaching and learning is to help learners construct a deep understanding of the subject matter and the processes involved. This is mostly achieved by allowing the students to infer, explore, create, test and verify solution to a given problem (Prince & Felder, 2006). In addition, PBL leads to attainment of knowledge by learners that enhances the development of important skills that empowers students with the ability to solve day to day

problems. Studies have also shown that PBL is positively correlated with high achievement levels due to frequent use of interactions that are inclusive (Newman, 2004).

Problem-Based Learning is viewed as a three staged process that involve the analysis of problem, solving the problem and reporting the outcome (Stokholm, 2014). This is unlike Design Based (DBL) Learning which (Stokholm, 2014, p. 1) view as "a series of integrated design spaces including; alignment, research, mission, vision, concept, product and process report, with focus on innovative ideation though integration." Much as both the PBL and DBL have a similar starting point, problems, learners' activities in PBL are directed towards studying while the activities for students in DBL focus on construction of artefacts (Stokholm, 2014). Thus with PBL, the nature of problems may vary from theory to practice, and problems are usually based on challenges in professional environments (Barge, 2010). In simple terms, the main aim of problems in PBL is to situate the learning with a particular context so as to generate knowledge with the guide of questions that are usually laid out by the teacher to keep the learners in line with the course objectives (Awang, 2007; Barge, 2010). On the other hand, problems in DBL focus on use of an interactive process aimed at transforming information and knowledge into creative and innovative ideas (Stokholm, 2014). Stokholm (2014) divided the design process into the analytical phase in which one is concerned with discovery and synthesis stage where individuals are concerned with invention and realisation. This is achieved based of questions that the learners raise depending of the design specifications. Overall, PBL is may be used to develop basic competencies and skills that a student would use in a design process to tackle design problems.

2.3.1 Characteristics of PBL

Problem-Based Learning has a number of characteristics. Educators identify these characteristics and utilise them in the designing of PBL curriculum. Firstly, PBL enhances the use of a number of senses at a time through promotion of observational skills. The students develop skills to observe the world around and use their experience in problem solving. In addition, PBL uses situations or experiments to promote professional practices. As such, it must have clearly stated objectives and appropriate resources for students' learning. In the same vein, PBL problems must be structured to reflect real life problems that are capable of developing an interest in the learners to seek solutions to problems. Furthermore, the curriculum is designed with learning experiences

that are practical to learners' field of learning and are intended to offer progressive and complex situations that promote development of skills in students.

Problem-Based Learning also encourages collaboration amongst students to create a conducive learning environment. This is achieved through use of small groups in the brainstorming stages of the problem at hand. The issue of scaffolding in PBL promotes student directed learning by controlling the students through set goals and objectives, timetabling, deciding the groups and setting learning outcomes. The learners must do independent studies based on the objectives and gather information to be used by the group to make decisions about the problem at hand. Problem-Based Learning promotes reflective learning whereby students take time to reflect on their learning experience strengths, weaknesses, challenges, deficiencies, remedies and assessment of achieved goals. Lastly, PBL encourages independent studies by students through reading and research (Newman, 2005; Savery, 2006; Williams et al., 2008).

2.3.2 Distinctive features of PBL

Problem Based Learning has attracted the attention of many educationists and policy makers. Some have supported the use of PBL yet others have heavily criticized it. It must be noted that to achieve the goals of PBL, there is need to implement the strategy correctly based on its features.

Firstly, PBL relies on teamwork where individuals bring with them different abilities and skills to achieve a group goal. It entails a number of issues including shared decision making, shared learning exercises and organization of tasks. Teamwork is perceived as critical in technology education as teams are normally used to solve technological problems in many countries (Williams et al., 2008). Thus group work exposes students to a working environment equivalent to that in the world of work. It promotes communication, adaptation, listening skills and organization skills. Teamwork also promotes collaboration skills amongst the students. The students are able to brainstorm ideas. Groups reduce fear of failure (Newman, 2005; Savery, 2006; Williams et al., 2008). Newman (2005) adds that where groups are carefully chosen, a conducive learning environment is created. Thus, he argues, carefully selected groups facilitate learning through development of cognitive and meta-cognitive skills. Newman (2005) also claims that learning in small groups aids the students to learn how to cope and deal with challenges of life. By putting students in groups, Newman (2005) argues, they become responsible for their

learning. They also develop facilitation skills that may be an important part of training they may take to their work places.

Secondly, PBL encourages research by students by emphasizing on the analytical skills of students. Thus, students are expected to gather information on the problem in question and then conduct an analysis of the information. It gives the students information gathering skills and use the ideas to support their case. Thus students develop the required outcome from an analysis of the problem at hand through the information gathered during independent study.

Thirdly, PBL encourages reflection on the process used and the end product through evaluation. Students are also given a chance to reflect on learning experiences they undergo during the problem solving process (Newman, 2005). Savery (2006) claims that reflection promotes peer and self-assessment. Thus the self-study and self-assessment enhances the self-reflection as required by Problem-Based Learning. However, Newman (2005) states that little research has been done to validate the use of PBL in training. He further claims that PBL has many variations in its implementation including some hybrid models like the Inquiry Based Learning model (IBL). He acknowledges that the IBL based on PBL though he categorically said that the two models are not necessary the same. In fact Williams et al. (2008) put the IBL model side by side with the PBL model as models of Problem-Based Learning. This implies that the two are similar. Newman (2005) indicates that the original PBL model developed in the 1960's by Barrow at Mc Master University aimed at addressing students' boredom in solving practical problems; students' inability to put what was learnt into practice; promote school to work transition where graduates failed to fit into the world of work. The rest of the professional training programmes are based around this with the help of theories for a particular field.

Fourthly, Newman (2005) and Savery (2006) highlight the importance of assessment in the process of learning where PBL is used. Newman (2005) argues that assessment drives the learning process especially when the assessment is well aligned with goals of the programme. He pointed out that multiple choice questions are out of favour for PBL since they are assumed to test low level cognitive functions. He, however, acknowledges that there is debate on the use of multiple choice questions in PBL with another section claiming that what matters is the quality of the test and its administration. Research shows more usage of modified essay questions (MEQs)

in PBL assessment. Newman argues that MEQs bring about realities of work and can measure abilities and attitudes that multiple choice cannot assess.

Lastly, students are responsible for their own learning (Savery, 2006). Thus based on the problem at hand, PBL encourages students to bring out what they know and search for information on what they need to know. This results in increased ownership of the learning by the students. This implies that in trying to find a solution to a problem, students take up the responsibility of searching and bringing information to the group. Savery (2006) also stresses the need to assess the process and the knowledge as PBL is both knowledge based and process based. Assessment needs to be regular to monitor students' learning from time to time.

2.3.3 Misconceptions about PBL

Savery (2016) argues that the adoption and use of PBL in different fields has resulted into many misconceptions and misapplications. He pointed out that there are some concepts that are considered PBL yet they fail to achieve the expected results that PBL is expected to achieve. He, therefore, outlines some sources of the misconceptions and misapplications. These include the use of assessment methods that do not meet the PBL requirements in matching with learning outcomes; insufficient information on nature and types of problems used; lack of knowledge and commitment of staff; and lack of learning resources and use of outdated learning resources.

2.4 Related studies on implementation and use of PBL

Meta-analyses of PBL have produced varying findings on the effectiveness of Problem-Based Learning. Debate has ensued on the best teaching methods to be used in the instruction to achieve optimum results in individual learners (Newman, 2005; Schmidt et al., 2007). There is contention between the use of traditional teacher-centred method of teaching and a shift to student-centred lessons. Schmidt et al. (2007) acknowledge arguments that some methods are a recipe for failure for novice learners as other writers claim that there is minimal guidance. However, Schmidt et al. (2007) argue that PBL is exceptional as it is flexible and can be adjusted according to the cognitive structure of an individual. This research investigated the effect of the use of PBL in Woodwork at The Malawi Polytechnic.

A study by Steinemann (2003) and Hung, Honassen, and Lui (2008) contend that students find PBL to be an effective approach to learning that engages students in meaningful learning through active participation of the learners. Thus the students appreciate the chance accorded to them by PBL to experience real-world challenges well before going into the world of work. The students feel that by owning the process of learning, they experienced valuable though challenging moments that enabled them to gain knowledge and skills through the problem solving skills gained (Steinemann, 2003; Hung, Honassen, & Liu, 2008). These research findings suggest that PBL has enjoyed a rich vein of success for over five decades now. It is an approach. Problem-Based Learning promotes deep understanding of concepts and long knowledge retention.

Problem-Based Learning has proved to be effective in most studies assessing the impact of Problem-Based Learning (Walker & Leary, 2009). Results of the studies show that students who study using the PBL perform better than those who study using the traditional lecture methods. Thus, according to Walker and Leary (2009), many studies show that the use of PBL has produced a number of statistically significant findings. However, Walker and Leary (2009) acknowledge that there are instances that the PBL students had performed the same way as the traditional method students. Despite these findings, PBL students are perceived to do better in providing concrete explanations to different phenomena.

While Hmelo-Silver (2004) acknowledges that a number of meta-analyses showed that PBL was ineffective, there are even more studies that suggest otherwise. It appears that the nature of the subject has an influence on the effective use of Problem-Based Learning. For instance, Hmelo-Silver (2004) highlights high performance of students in clinical knowledge than in basic science knowledge. Steinemann (2003) indicates that engineering education has benefited from the use of PBL as it promotes active learning, professional skills, problem solving skills, applicability of learning and motivation to learning. In other words, the use of PBL has made knowledge more accessible. This has led to its applicability to solving problems in real life.

Another analysis by Dochy (2003) shows no effect of PBL on declarative knowledge but shows no effect knowledge application. Literature also suggests the success of PBL in engineering education (Steinemann, 2003). Kirschner, Sweller, and Clark (2006) view PBL as a minimally guided approach to teaching and learning. They argue that these minimally guided approaches are

ineffective and inefficient. As such it promotes back-ward driven reasoning (Kirschner et al., 2006). They, therefore, contend that this is not a healthy situation as the error created in problem solving at this stage may prove persistent in the learners. However, Walker and Leary (2009) wonder as to how despite this negativity, PBL students mostly perform better than the traditional approach students. The higher performance by PBL students is a clear indication that the backward reasoning still has some merits and has led to improved students' performance for the students learning through PBL, hence the need to engage the students using the Problem-Based Learning.

Several authors have acknowledged that PBL has proved to be more time demanding than it appears on the surface (Marincovich, 2000; Forsythe, 2002; Steinemann, 2003). The preparation, administration and evaluation of the PBL can be cumbersome and tiring as it demands seeing the learners through difficult times. Thus if compared to the traditional approaches, PBL demands more effort and attention to deliver it successfully. While traditional methods rely mainly on standardised test, the use of PBL requires the evaluation of the learning process, which may prove challenging.

Kirschner et al. (2006) base his argument on human cognitive architecture, cognitive load and expert-novice differences. He claims that the minimally guided approaches ignore the structures of human cognitive architecture. Human cognitive architecture is a theory that tries to explain the structure of the human mind. Thus it is expected that the effectiveness of an instruction is dependent on the match in the characteristics of human cognition. They help in the designing of learning environments that match the real world. Sweller (2008) claims that there can never be specialised instructional procedure for an institution. According to Hmelo-Silver (2004), PBL is not a minimally guided instruction as it affords the learners with scaffolding and guidance to the learners. Contrary to claims by Kirschner et al. (2006) that there is evidence against PBL, Hmelo-Silver (2004) claims that there is equally enough empirical evidence supporting the effectiveness of Problem-Based Learning. It is, therefore, perceived that the difference in the views as originating from the theoretical orientations of the individual. Kirschner et al. (2006) claims that there is minimal guidance in Problem-Based Learning. But he notes that with the PBL, the teacher as a facilitator must always be available to provide guidance to the learners at any stage

of their study. There is need to provide literature from where the learners must access information while at the same time according them the freedom to read wide for different views. This provides the learners with deep understanding of knowledge and its epistemological view point (Hmelo-Silver, 2004).

Newman (2004) discusses the importance of the inclusion of control group in PBL experimental studies. He argues that most studies do not have control groups. As such, this limits the conclusions that are arrived at from such studies. There is also selection bias that likewise limits the conclusions. The major challenge to the implementation of PBL is in striking a balance between the freedom accorded to the students as they seek solutions to problems at hand and scaffolding the process of learning so that the students do not become frustrated by what they may view as meaningless efforts in instances they may feel lost (Steinemann, 2003). Thus much as the students need guidance from the teacher, the teacher must be careful not to divulge everything to the students. Students may get demotivated in the process of learning. Therefore, it is the task of the teacher to make sure that the students keep on going. Thus the teacher must sustain the intrinsic motivation of the learners (Steinemann, 2003). As PBL involves group work, there is need that team spirit is promoted so that the learners move together as a unit.

In addition, the implementation of PBL has proved to be a challenge to many students especially in the initial stages (So, Yeung, Lo, & Volk, 2001). Teachers and students have become frustrated at times due to the cumbersome nature of the approach. The approach is demanding and requires time and dedication from both the lecturer and the student. However, So et al. (2001) acknowledge that students are able to catch up with the demands of the PBL as time passes.

Hmelo-Silver (2004) also highlights studies that indicate that moderate effect size favours Problem-Based Learning. A study by Patel, Groen and Norman (as cited in Hmelo-Silver, 2004) shows that students who once used PBL tend to transfer those skills to other problems, which is not the case with those students that have always used traditional methods. The study also revealed that students that employed PBL strategies in their studies made a lot of errors. However, the results revealed that despite the errors, PBL students made some well elaborated explanations as compared to the shallow explanations made by students who were engaged in

traditional approach (Hmelo-Silver, 2004). This simply is a result of their engagement during learning that the more they research, the more errors they make and the more concrete information they gather. The current research notes that the differences mirror a battle between advocates of expert data-driven reasoning strategies as spearheaded by those advocating for the traditional methods against hypothesis-driven reasoning strategy as advocated by those supporting PBL approach. However, it must be noted that dared by some unfamiliar phenomenon, we all opt to go for hypothesis-driven reasoning (Steinemann, 2003; Hmelo-Silver, 2004).

Another recent study by Dochy (as cited in Hmelo-Silver, 2004) indicates that students that learn using PBL approach produced more accurate and lucid solutions to problems as compared to those learning under the traditional approaches. A study by Derry, Levin, Osana, Jones, and Peterson (2000) shows that there was statistical significance favouring the use of PBL for students studying statistical reasoning in educational psychology. At secondary school level, Mergendoller, Maxwell, and Bellisimo (2006) compare the use of traditional approaches to PBL approach. The study reveals that students using the PBL gained more knowledge than those using traditional approach.

Problem-Based Learning has registered success in the medical industry for over fifty years (Hung et al., 2008). It was however, observed that the success of PBL depends on the nature of the problem. Thus models are used in designing of problems that are used in Problem-Based Learning. One such model is the 3C3R PBL problem designing model discussed by Hung et al. (2008). The model has two components; the core component and processing component. It is the core component that has the 3C namely content, context and connection. The 3R is found in the processing component and it includes researching, reasoning and reflecting. The model is meant to promote students' cognitive process and improve their problem solving skills.

2.5 Theoretical framework

There are many instruction models that are used in education. Most of these models are more aligned to problem solving (Biggs, 1996; Tam, 2000). Williams (1992) gives an example of case-based learning that is mostly used in business and law schools as most widely used problem-centred instructional approaches. In PBL, instruction is centred on some well described events that present a challenge to the learners. This study was built around the constructivist theory of

learning. Constructivism is modern-day theory of learning that is built on the premises that learners are active participants in the construction of knowledge (Foston & Perry, 1996; Kemp, 2011). Thus based on prior knowledge, individuals have the capacity to build their own knowledge and understanding of the world (Novak & Canas, 2004). Constructivist theorists are not only concerned with the end itself, but also the means to that end. As such, their perspective of learning is that it is personal and requires the learner to be on the forefront. Thus learning is not all about receiving and processing of information from teachers or texts (Savery & Duffy, 2001). Woolfolk (2007) agrees with this by pointing out that the constructivist theories of learning put their focus on how individuals learn; how they view the world around them through interaction with others. Constructivism contends that conceptual development is a result of disequilibration (Slavin, 2003). This implies that individuals learn better when they are dissatisfied with what they know already. From the dissatisfaction, individuals develop the dire need to modify their knowledge through classes, individual studies and group discussions. This shows that constructivism is a broad term concerned with cognitive psychology that has led to new approaches to teaching and learning.

There are a number of psychologists who contributed much towards the constructivist theory of learning. These include Piaget, Vygotsky, Bruner, the Gestalt psychologists, Bartlett and John Dewey (Seifert & Sutton, 2009). What is more important with the constructivist theory is that it is overarching and interdisciplinary in nature (Yilmaz, 2008; Kemp, 2011). Yilmaz (2008) highlights the diverse nature of the constructivist theory with its base on philosophy, sociology, psychology and critical educational theories.

Thus, this section discusses the instructional design that is grounded on the constructivist assumptions of knowledge and learning process as perceived from PBL approach perspective. Problem-Based Learning approaches encourage knowledge construction by students, as such, it is considered to be constructivist approach to learning. Constructivism as a learning theory views a learner as a chief architect in the learning process (Barr & Tagg, 1995). This is in line with PBL which views a student as an active learner. Thus knowledge constitutes some frameworks that are learner constructed. Just as learning requires the learner to develop an understanding of concepts through independent studies in PBL, the constructivist theory views a learner as the constructor of knowledge (Barr & Tagg, 1995). Specifically, PBL is grounded on both cognitive and social

constructivism. The following subsections discuss the orientation of the PBL approach towards cognitive and social constructivist views.

2.5.1 Cognitive constructivism and PBL

Contrary to the behaviourist views that learning involves knowledge absorption by a passive learner, the cognitive constructivist theory presumes that cognitive structures play a big role in knowledge development and that the learners are actively involved in the knowledge construction (Reynolds, Sinatra, & Jetton, 1996). Bodner (1986) argues that the construction of knowledge is based on cognitive structures that exist already. Thus knowledge constructed depends on past experiences that are represented mentally through active and intentional activities. This is in line with PBL approach which considers a learner as an active participant to the learning process. Cognitive constructivism contends that individuals interpret information and experiences differently. The basis for interpretation is the stage of cognitive development, cultural background, existing knowledge and personal history (Bodner, 1986; Glaser, 1988). Thus interpretation of information is dependent on an individual's viewpoint.

The thinking has changed based on constructivism which acknowledges that learners can build their own knowledge at different paces (Bell & Mitchell, 2000). The constructivism theory also considers that the learners can demonstrate that they have learned by demonstrating their ability in the areas of study (Deibinger & Hellwig, 2011). Thus learners must portray in them the intended outcome called competencies that were intended to be transferred to them. This represents a shift from the mechanical telephone exchange analogue that looks at learners as passive observers to the computer analogue in which students are considered to be active processors of information. In these new theories, the learners must take in some information through research and teachers, process the information and then give out the desired output. Thus theories are now built around the new cognitive psychology which places emphasis on conceptual development (Atkins & Brown, 2002). Cognitive psychology provides the platform for the advocacy for the learner-centred approaches to teaching and learning (Novak & Canas, 2004). Research indicates that memory is affected by the way knowledge gained is processed (Sawyer, 2004). Rote learning that promotes simple listening and recalling of the same factual matter results in easy loss of information. However, experts argue that learning should promote establishment of relationship among prior knowledge, what is to be learnt and the learning

experiences. Thus learning should allow students to question some issues and be able to explain them in their own understanding. In doing so, the learners develop conceptual understanding of the subject matter and are more likely to remember the knowledge they built. One way of achieving this is through the use of Problem-Based Learning. Therefore, a trend in Technical and Vocational Education has been to shift from the traditional teacher-centred methods to learner-centred methods.

The cognitive constructivism theory views learners as active participants in the process of learning through which they integrate new knowledge to the already existing cognitive structures. This entails that learning is a process of active discovery by learners (Prawat & Floden, 1994; Foston & Perry, 1996; Mayer, 2009). This represents a shift in the role of a teacher from the drill knowledge through repeated factual literature and the use of reward and punishment to the view that a teacher is a facilitator who provides resources. The development of curriculum thus takes into consideration the existing knowledge of the learners from which the learners will build new knowledge through a structured sequence (Prawat & Floden, 1994; Foston & Perry, 1996; Mayer, 2009).

Motivation of learners is very important to the teaching and learning process. The cognitive constructivist theory contends that motivation in learners is intrinsic (Oldfather & Dahl, 1994; Dai & Sternberg, 2004). Thus learners set their own goals for learning. This implies that the learners have to motivate themselves in order to learn. This is contrary to the views held by behaviourists who suggest that learners are motivated externally by use of rewards and punishments. Cognitive constructivists hold that learning involves the restructuring of existing systems of knowledge. As such, learning is a personal investment hence requiring intrinsic motivation. The learners need to demonstrate some dissatisfaction with the existing knowledge so as to yearn for a modification or abandoning the existing knowledge (Dai & Sternberg, 2004). This implies that extrinsic motivation through rewards and punishment may prove to fail where individuals do not have an internal drive to learn.

Teachers assume varied roles in teaching and learning process. The roles of a teacher are varied depending on the philosophical point of view held by an individual. The cognitive constructivism theory is aimed at helping the learners to acquire knowledge by taking in new knowledge and

integrating it with the existing knowledge (Saunders, 1992; Tam, 2000). Thus the theory views teachers as facilitators to the learning process. This means that teachers and learners must develop strategies meant to make the learners active participant despite circumstances that call for skill and drill exercises in the uptake and absorption of lists, facts and formulae. Their task is to provide a conducive environment to learning that must promote discovery and integration of new knowledge.

Due to the fact that learners must be self-motivated as viewed by the cognitive constructivism, it is also suggested that learners must monitor their own learning. This can be achieved through the use of ungraded tests and review questions. The students may also use reflective or learning journals to check their progress in their learning.

2.5.2 Social constructivism and PBL

Social constructivists contend that culture and context play an important role in knowledge construction. The theory is built around the developmental theories of Vygotsky and Bruner, and Bandura's social cognitive theory (Shunk, 2000). Social constructivism is based on assumptions about reality, knowledge, and learning. Firstly, social constructivists hold the view that human activity plays a role in construction of reality. They argued that reality cannot be discovered. However, it can be invented by members in a given society (Kukla, 2000). Furthermore, social constructivists believe that knowledge can be created by humans through social and cultural interaction (Prat & Floden, 1994; Gredler, 1997; Ernest, 1999). This means that interaction with members within a group and the surrounding environment help individuals to create meaning of objects. Thus learning is viewed as a social process by the social constructivists. It is individuals partaking of the social activities that result in learning. In this perspective, learning is a product of historical developments that a learner has inherited over time as a member of a given society and symbol systems that dictate what is to be learnt and how to learn it. The symbol systems include language, logic, and mathematical systems. In addition, learning occurs when the learners interact with knowledgeable members of a society.

Social constructivists hold four perspectives that shape learning (Gredler, 1997). The first is the cognitive tools perspective that considers students engagement in learning activities that accord them hands-on experience to be important (Prawat & Folden, 1994; Gredler, 1997). It focuses on

the learning of cognitive skills and strategies in which the learners as a group produce a product and give meaning to the product through the social learning process. The second is the idea-based social constructivism that emphasizes on learners' ability to construct meaning of scientific concepts. Thus the concepts of various disciplines become the priority of education. (Prawat & Folden, 1994; Prawat, 1995; Gredler, 1997). The third perspective is the pragmatic approach in which social constructivists hold that knowledge, meaning, and understanding of the world can be addressed in the classroom from both the view of individual learner and the collective view of the entire class (Cobb, 1995; Gredler, 1997). As such, the implementation of social constructivism in class should be emergent as the need arises. Lastly, the transactional cognitive perspectives that contends that humans are a part of the constructed environment. Therefore, it focuses on the relationship between the people and their environment (Bredo, 1994; Gredler, 1997). It argues that an individual interacts with the environment as his mind is in operation. This means that learning cannot take place without considering the environment as social meaning of an object may change depending on the environment (Bredo, 1994; Gredler, 1997).

All in all, social constructivists call for instructional models that stress the need for collaboration among learners and with practitioners in the society (Lave & Wenger, 1991; McMahon, 1997). Therefore, learning is a product of knowledge and practice (Lave & Wenger, 1991; Gredler, 1997). This makes PBL approach fit as a social constructivist approach.

2.6 Chapter summary

This chapter on literature review has discussed the theoretical framework for the study. It has discussed the two main paradigms to teaching and learning; the teacher-centred learning and student-centred learning. It has highlighted the principle of the two orientations to teaching and learning approaches as well as their advantages and disadvantages. The discussion recognized that many teachers like using the teacher-centred approach. However, more literature pointed out on the need for paradigm shift from the teacher-centred to the learner-centred approach to improve learning and knowledge retention through self-directed learning. Thus the discussion showed that self-directed learning has the ability to improve cognitive and skills development that is required in problem solving.

The chapter gives an overview of PBL as a teaching and learning approach that is learner-centred. It focused on its history from the early 1960s and how it has been adopted for use in different fields of study. Literature shows that many studies on PBL have been conducted since its inception. The section discussed the findings of such studies as a way of supporting this study which investigates the effectiveness of the use of PBL to enhance technical student teachers' understanding of Woodwork concepts. My argument is that initial years of practice are problematic for teachers and that this is mostly caused by the theory and practical divide. This must be more evident in technical subjects as teachers must demonstrate both understanding of the subject matter and the practical aspect. This research is very specific to technical teacher training in Woodwork at The Malawi Polytechnic. The vision 2020 targeted Malawi to be a technologically driven economy by the year 2020. However, little progress, if any, has been recorded due to lack of workforce with such skills to move the country forward technologically. Therefore, as a way forward, the study intends to show that the use of PBL in technical teacher training has the potential to play a very important role in technology advancement as PBL enhances collaboration and teamwork which are essential for problem solving in the real world.

The researcher is of the view that the findings of this study may influence a larger study on technical teacher training in all courses under the Technical Education programme. Thus, this will lead to the production of technical teachers who are up to the task in promoting lifelong learning when they start teaching at different levels. This implies that they will be able to translate what was covered in their training into practice with ease. Such teachers trained using the PBL approach will be able to work effectively and create an environment necessary for imparting critical thinking and creativity in the learners. Therefore, all the aspects discussed in this chapter are used to inform my study on the implementation of PBL in Woodwork at the Malawi Polytechnic.

CHAPTER THREE

METHODOLOGY

3.1 Chapter overview

The research sought to help students develop problem-solving skills which they would use in the real world concerning woodwork. It intended to enhance critical thinking and creativity in the learners through the use of PBL approach to teaching and learning. In particular, the research evaluated the cognitive and skills development of the students using PBL as compared to those using traditional approach. It further sought to develop an understanding of students' views on the use of Problem-Based Learning. This chapter discusses the approach that was adopted and the methodology that was used in conducting the research. The chapter describes the research philosophy and research design that were taken into consideration when designing the investigation. It further explains sampling methods, data collection techniques and data analysis techniques.

The study intended to utilise the research onion framework. According to Saunders, Lewis, and Thornhill (2003), a study has different layers that can be represented using the research process onion. The first layer of the research onion has research philosophies that discuss set of beliefs and nature of reality under investigation; second layer shows the research approaches that may be used while the third layer having research strategies; the forth layer shows a number of choices that the researcher may choose from and the fifth layer indicates the time horizons. The last has data collection techniques. The research onion is shown in Figure 3.1;

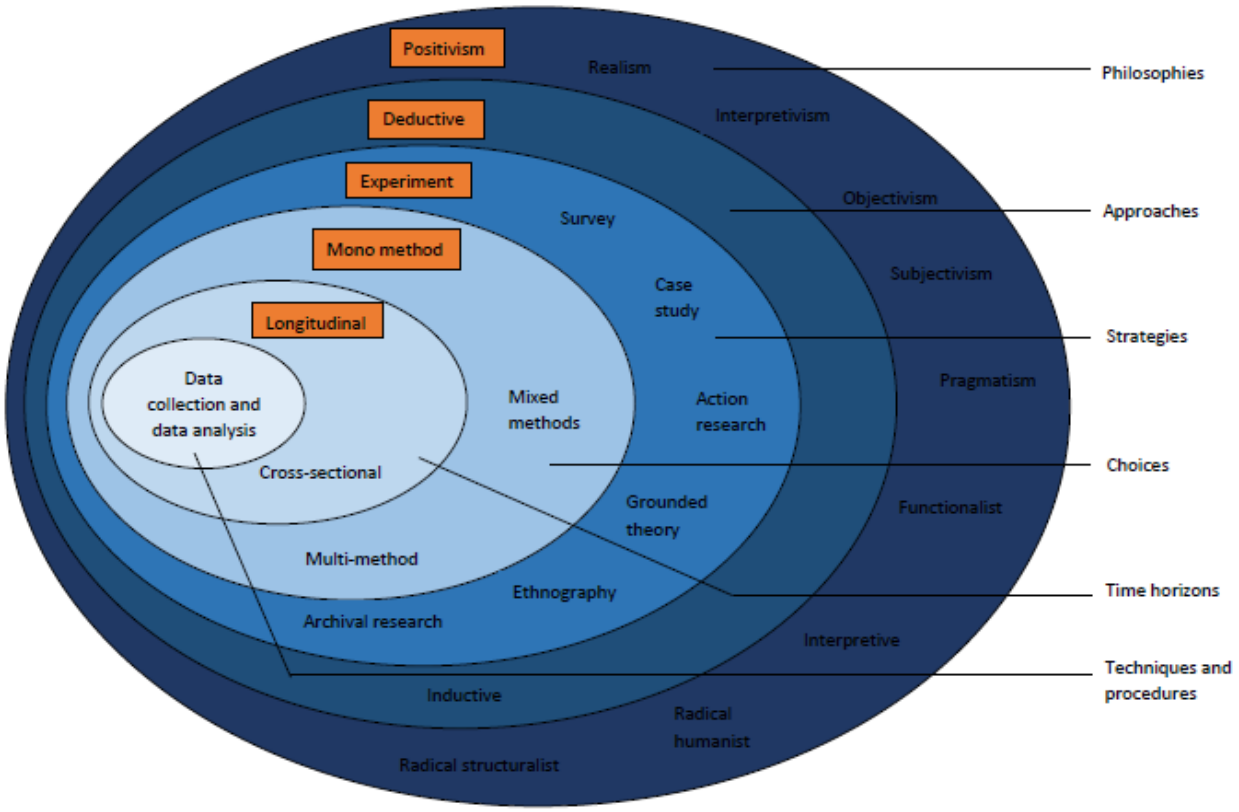

Figure 3.1: The research onion (adopted from Saunders et al., 2009)

The research onion guided the study in step by step creation of the process that saw the establishment of a solution to the study (Saunders, Lewis & Thornhill, 2009). It offers increased reliability and validity of the study (Saunders, Lewis & Thornhill, 2003).

3.2 Research paradigm

Barr and Tagg (1995) and Creswell (2009) define the word paradigm as a set of philosophies that sets out rules of engagement in a research. This means that research paradigm is meant to define the playing field. It also seek to define the breadth and depth of play in the field. It provides a scientific process that is valid and reliable for conducting a research (Saunders et al., 2009). It answers the question as to how the study is to be conducted. This means that whatever methodology is considered must be directly linked to the research paradigm that had been chosen. The methodology needed to reflect what was defined in the domains of the research paradigms.

This research was inclined towards the positivists approach as most of the data to be collected was quantitative in nature (Cohen, Manion, & Morrison, 2005; Saunders et al., 2009). Positivism is sometimes referred to as postpositivism or empirical science (Creswell, 2009). Positivists contend that there exists a reality that is governed by laws of cause and effect (Saunders et al., 2009). In this type of study, the researcher is objective as he or she is guided by these laws. Using the positivist views, the findings of the study can be generalised since they are statistically reliable and objective (Saunders et al., 2009). This is based on the ideas that human nature is shaped by external factors (Saunders et al., 2009). According to positivists, this means that a given cause will produce same effects in different individuals; hence the generalisation. In addition, the probabilistic nature of the positivists approach makes it even easier for the generalisation of the findings as they hold true for a larger group of people (Cohen et al., 2005; Gay, Mills, & Airasian, 2011). Where the instrumentation is properly done, positivism allows for accuracy and certainty on the findings (Saunders et al., 2009). It allows for knowledge building from theory-driven hypotheses that can be verified (Saunders et al., 2009). This leads to the systematic description of knowledge based on the facts and laws. In this instance, the propositions of the finding are used to explain the causal relationships between the two variables (Cohen et al., 2005; Saunders et al., 2009). Specifically, the variables in this study are the teaching approaches (PBL versus traditional method) and the performance of the students.

3.3 Research design

The positivist approach allowed the study to use the experimental research design in which the causal relationship of an intervention on the performance of students was investigated (Cohen et al., 2005; Creswell, 2009). The research allowed for direct manipulation of variables and making of observations that allowed statistical analysis of the findings in the process of verifying the hypothesis (Cohen et al., 2005; Saunders et al., 2009).

A research strategy is more concerned with how the study will answer the research questions or address the research objectives (Saunders et al., 2003). Hakim (2000) and Myers, Well, and Lorch (2010) refer the research strategy to as a research design. Bryman (2004) agrees with Saunders et al. (2009) that selection of a particular strategy is dependent on its ability to meet the objectives of the study. Thus the quality of a study is as good as its research design. Research design is the setup of conditions that are laid by a researcher for collecting and analysing data

(McMillan & Schumacher, 2010). It also describes how the data is collected from who and when (Saunders et al., 2003; Gay et al., 2011). Welman, Kruger, and Mitchell (2007) view a research design as an action plan with a link between research methods and procedures with the aim of acquiring reliable and valid data for the study. The purpose of a research design is to consolidate research purpose and relevance of the study (McMillan & Schumacher, 2010). Thus there must be a positive correlation between the research problem and research objectives. As per the discussion above, there are many approaches to conducting a research. In other words, the research design provides a framework that guides research decisions. These include survey, experiment, case study, grounded theory, action research and ethnography (Saunders et al., 2003; Gay et al., 2011). The choice of the approach to be used depends on the purpose of the study. Thus the choice of a research design is based on the focus of the study and the merits and demerits of different research designs. It must be noted that the research design guides the choice of data collection tools to be employed that will provide the researcher with as much information as possible.

This study used the experimental design as it sought to collect data that was used to evaluate the effects of a specific intervention, teaching through PBL, on students' understanding of Woodwork concepts (McMillan & Schumacher, 2010; Gay et al., 2011). Thus the nature of the research is an intervention in which the study intended to compare the effect of the use of PBL approach to traditional approach. This makes the experimental design essential for the study (McMillan & Schumacher, 2010). McMillan and Schumacher (2010) further indicate that experimental designs are mainly used to investigate the cause and effect relationship between the experimental treatment and the measured outcomes. The major advantage of using the experimental approach is that the results can be generalised especially when the experiment is conducted in its natural environment with controls over critical variables that may affect achievement (McMillan & Schumacher, 2010).

Experimental research is the study of the relationship between two variables (Ary et al., 2006; McMillan & Schumacher, 2010; Gay et al., 2011). It involved a methodical manipulation of one variable and observation of its effects on another variable. Ary et al. (2006) refer to the variable that is changed as an independent variable or an experimental treatment while the other variable to be observed is called the dependent variable. In the study, two methods, PBL and traditional

approach were used and the results of achievement test were compared. These two pedagogical methods formed the independent variables while the scores from the achievement tests were the dependent variable.

Ary et al. (2006), McMillan and Schumacher (2010) and Gay et al. (2011) point out that in an experiment, apart from the independent and dependent variables, there might be other variables that would affect the results of the experiment. Use of experiments demand that such other variables be kept constant. In this study, an attempt was made to ensure that the two groups have the same assessments, lecture notes and readings. In addition, the groups will have same number of people with same gender ratios. In fact Gay et al. (2011) compare experimental design to casual-comparative research arguing that what makes experimental design more important is its ability to allow for manipulation of one variable in an attempt to observe its effects on another while controlling other variables that may have an effect on the outcomes in a cause and effect study. Experimental design allows for selection of participants, putting them into different groups with same characteristics and then exposing them to different experimental treatment to study the cause and effect relationship (McMillan & Schumacher, 2010; Gay et al., 2011).

To be specific, the study employed the pre-test-post-test control group design. The pre-test-post-test control group design is demonstrated in Figure 3.2:

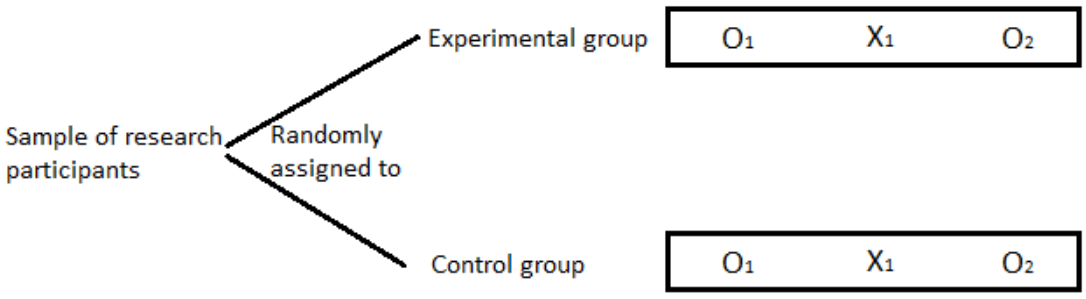

Figure 3.2: Pre-test-post-test control group design (adapted from Ary et al., 2006)

According to Ary et al. (2006) and Johnson and Christensen (2011), the pre-test-post-test control group design is a design in which the researcher administers a pre-test to both the experimental group and control group. An intervention is then implemented with a post-test at the end of the intervention. The two groups in this study were exposed to both PBL and traditional approaches at different times to allow the participants to compare the two approaches and share their experiences. Thus the participants were able to give their perceptions on the use of PBL

approach. Ary et al. (2006) and Johnson and Christensen (2011) contend that this design is good as it helps in controlling rival hypotheses. In addition, it also helps to control history and maturation as threats to internal validity because the control group experiences whatever is experienced in the experimental group.

3.4 Population and sampling strategy

The study took place in the researcher's own Woodwork classroom at The Malawi Polytechnic. This was a first year Woodwork class. The research involved the study of the effect of PBL on students' understanding of Woodwork concepts. It entailed that the study be conducted in the Woodwork class that the researcher was already teaching. The study involved 62 participants in a Production Technology (Wood II) class. The class was divided into two groups to form the experimental treatments. Random stratified procedure was used to assign students to experimental treatments. The class was first stratified into two groups based on gender. This was done to make sure that each gender was equally represented in each group. This acted as a control where some people would feel that gender disparities between the two groups might influence the outcomes.

Then a random process was employed to divide the different genders into two groups. The female students picked papers with number 1 or 2. Likewise, the male students also picked pieces of paper with numbers 1 or 2. All those who picked 1s formed the experimental group where as those that picked 2s formed the control group. The use of the random process is very important as it gave the participants equal opportunities to be assigned to any group (Bonk & Cunningham, 1998; McMillan & Schumacher, 2010). This helped to get rid of personal opinion in the assigning of the participants. In addition, the characteristics of the participants do not influence the group to which a participant belonged. Table 3.1 shows the statistical summary of the participants of the study.

Table 3.1: Descriptive statistics of the sample

Variable	**N=62**	**Frequency**	**Percentage (%)**
Gender	**Female**	23	37.1
	Male	39	62.9
Age	**15-18**	3	4.8
	19-22	49	79.0
	23-26	7	11.3
	27-30	1	1.6
	Over30	2	3.2
Previous school attended	**High school**	1	1.6
	National secondary	24	38.7
	Conventional secondary	11	17.7
	CDSS	11	17.7
	Private schools	15	24.2

Out of the 62 participants, 23 were female representing 37.1% while 38 were male representing 62.9%. It was noted that 79.0% of the participants were in the age group 19-22 while 4.8%, 11.3%, 1.6% and 3.2% were in the age groups 15-18, 23-26, 27-30 and over 30 respectively.

3.5 Research hypothesis

A hypothesis is a guessed answer to a problem (McMillan & Schumacher, 2010). In an experimental design, a theory-driven research hypothesis is very critical as the findings of the study are meant to support or otherwise discredit such claims as stipulated by the hypothesis. As discussed in Chapter Two, PBL approach to teaching and learning is constructivist in nature. Research has shown that the constructivist approaches to teaching and learning are more effective as they promote students' participation (Moussiaux & Norman, 1997). The study had two hypotheses as follows;

1. The use of PBL is essential in enhancing students' understanding of Woodwork concepts.
2. Students who had earlier learnt using PBL will continue to employ PBL skills and maintain their performance.

Thus the assumption is that the use of PBL approach to teaching and learning will result in higher scores for students.

3.6 Data collection procedure

Deciding the methods of collecting data is one of the most important elements in any research work (Popov & Bourenkov, 2003). Thus data collection must be properly planned. If compromised, it affects the reliability and validity of the study. In this paper, the theoretical propositions guided data collection and ensured that the quantitative nature of the study is maintained. The research involved the implementation of an intervention in real class situation with the aim of analysing achievement scores to determine the effectiveness of Problem-Based Learning. As such, required data for the study was generated using achievement tests in an experimental design. Thus assessment tests were used in order to get students' scores to assess students' learning and engagement using the two approaches.

It must be noted that even though different methods were employed in the teaching and learning of the two groups, the groups were subjected to the same assessment tests. The scores for the participants provided the much sought for statistics to measure the impact of the intervention on performance. The following instruments were used.

3.6.1 Achievement tests

At the beginning of the semester, the participants in both the experimental group and control group sat for same pre-test assessment. The aim of the pre-test was to determine the amount of prerequisite knowledge that the participants had before the intervention was implemented. The baseline assessment, as pre-test is sometimes called, also helped in the identification of areas that need more concentration. Mid way through the semester, the first post-test assessment was administered with the aim of establishing the effectiveness of PBL approach. The two groups then swapped the learning approaches. That is to say, each group was exposed to the experimental as well as the control treatments. Most studies referred this approach to as the rotational design and that its aim was to address any uncertainties in the results that may arise from differences in group characteristics.

However, the swapping of the methods was necessitated by hypothesis 2 and ethical reasons. Having observed the effectiveness of PBL from the first post-test, it was unethical to deprive the control group of the experience an approach that had proved effective on the performance of the experimental group. Being students from the same class, the swapping of the approaches between the experimental group and the control groups ensured that each student was exposed to the same treatment, hence being accorded a leverage in performance. At the end of the semester, the participants sat for the second post-test assessment. The function of the second post-test assessment was to establish if the performance of students who were once exposed to PBL is maintained after withdrawing the approach.

Tests with different items were used for the pre- and post-test assessments. The approach represents a shift from the normal practice among different researchers who used the same tool for pre-test and post-test in quasi-experimental design to investigate the effect of an intervention. The test items in the three examination papers were categorised to measure different abilities in students. Therefore, having different items for pre- and post-test did not matter but what was important was the abilities the items were measuring. The items contained in these assessments tested same concepts as the pre-test, though the questions were different. The ability measured included knowledge acquisition, knowledge understanding, knowledge application and analytical skills. The assessments contained short answer and essay questions.

3.6.2 Attitude questionnaire

A questionnaire was also administered to the participants as a means of collecting data for the survey to establish students' views on the use of PBL and traditional approach. A questionnaire is simply a list of questions requiring responses for research purposes. It must be noted that there is need to define the topic of each question clearly and at the same time specify the perspective for answering the questions (Akbayrak, 2000). Matell and Jacoby (1971) list the following as advantages of questionnaires:

1. They are cheap
2. They require less amount of time to administer
3. Participants are ensured of anonymity. This helps to generate quality responses
4. They increase confidentiality as no names are required
5. Self-administered questionnaires increase response rate
6. They are easy to analyse through statistical methods

The questionnaire items employed a Likert scale to generate specific responses so as to simplify coding for quantitative analysis methods. Bertram (2012) defines a Likert as a response scale used to obtain participants' agreement to a given statement. The common scale is a 4-point scale as shown below (Betram, 2012).

1	2	3	4
Strongly disagree	Disagree	Agree	Strongly agree

In analysis, Likert scale allows independent analysis of each item or in unison with other items. Advantages of Likert scale are:

1. It is easy to construct
2. It produces reliable data
3. It is easy to complete by participants
4. It offers uniformity of measurement
5. Replies fit the needs of the researcher

The main disadvantage of the Likert scale is that the responses may be inappropriate for other participants. This increases chances of biasness since the researcher forces the respondents to choose from available responses proposed by the researcher.

3.7 The pilot study

The questionnaire was pilot-tested at The Malawi Polytechnic with students doing second year of Bachelor of Science in Technical Education. The pilot study was done with the aim of checking the clarity of the items as well as the ability of the items to discriminate respondents. The pilot study also tested the clarity of instructions and the completion time for the questionnaire. Ten participants consented to take part in the pilot study and filled the 5 point Likert scale questionnaire as indicated below.

1	2	3	4	5
Strongly disagree	Disagree	Not sure	Agree	Strongly agree

The participants were briefed about PBL approach and their responses were based on the brief other than experience of the approach. However, it was believed that having learnt woodwork in their first year and having been briefed about PBL, they would be able respond to the items in the questionnaire.

Several observations were made from the results of the pilot study. The participant took about 10 minutes to fill the questionnaire. It was noted that most students were marking ‘not sure’ for most items. This presented a challenge where if the responses were to be similar in the actual study, the study would not have raised the required data as regards students’ attitude towards Problem-Based Learning. With such responses, the study was not able to discriminate between the respondents. This resulted in changing from a five point Likert scale questionnaire to a four point scale (See Appendix 4). It was also observed that some of the items on the questionnaire were not in any way tackling any issue to do with attitude towards the PBL approach. Rather, these questions were bent towards students’ attitude towards the course, Woodwork, in which the study was to be implemented. Such items were completely removed from the questionnaire.

3.8 Assumptions of t-test

T-test, like any other statistical procedure, is carried out under some assumptions. In most cases, violating the assumptions results in the undermining of the findings of the study. It is, therefore, recommended that these assumptions be satisfied before the study is carried out. This study employed a positivist approach and used the t-test to analyse the collected data. The t-test was used on assumptions that:

1. The data to be collected was continuous.
2. The data was collected from two independent groups that were randomly assigned.
3. Equal variance existed where standard deviations are almost equal.
4. The data collected was normally distributed.

It must be noted that although Garson (2012) argues that moderate violation of the assumptions bear little or no effect at all, this study satisfied all the assumptions. Firstly, data for the study on the effect of PBL on students' performance was collected using achievement test. This meant that scores for students were used and they fall under continuous data category. In addition, the students in the experimental and control group were randomly assigned and one group did not have an influence on the results of the other. Furthermore, Levene's test for equal variance was conducted to check the reliability of the sample. It was established that the significance value is 0.948 which is greater than the significance level of 0.05. This means that the assumption is correct and that the two groups have equal variances and they can be treated as equal. Thus the assumption of homogeneity of variances has not been violated. This is evident in equal t-statistic of -1.064 and an insignificant difference in the degrees of freedom. Lastly, the skewness of the pre-test scores was 0.085. This suggested that there was no extreme departure of the data from normality. This was also confirmed by the visual inspection of the histogram of the same data shown in Figure 3.3.

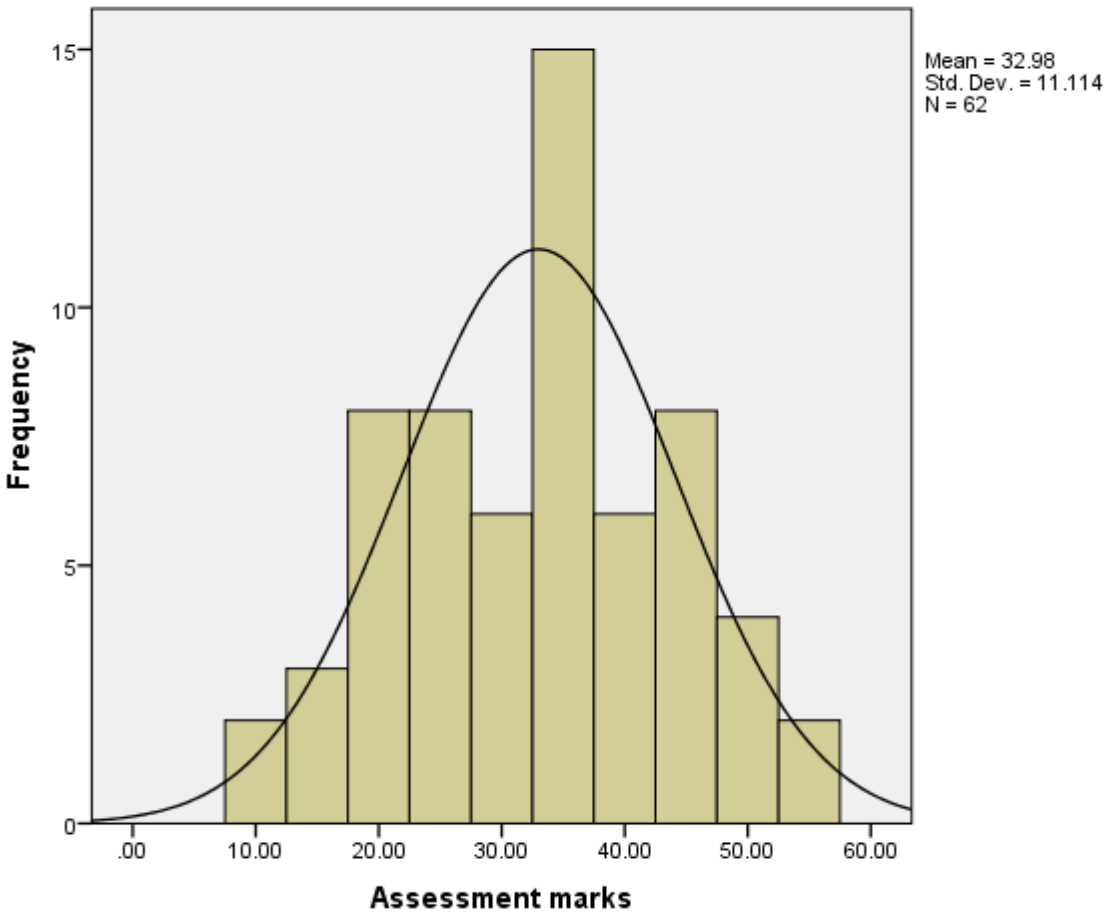

Figure 3.3: Distribution curve for pre-test scores

The 0.085 value fall between -0.5 and 0.5 and is close to 0. This indicated that the data is fairly symmetrical and that the data is normally distributed.

3.9 Data analysis

The research was expected to collect both descriptive and inferential data. The quantitative data was analysed using the Statistical Programme for Social Scientists (SPSS) version 20.

3.9.1 Test results

The test results for the pre-test and post-test were analysed by calculating the mean scores for the two groups and their standard deviation. The results for the two groups were compared to establish any significant differences. As a result, t-test for independent samples was used so as to achieve a comparison that helped to identify any differences that might have existed (Ary et al., 2006; Gay et al., 2011). The statistic in this study is the difference between the mean of two groups taught using different teaching approaches; one taught using the traditional approach and the other taught using the Problem-Based Learning. Therefore, the t-test for independent samples provided a ratio that is derived from the quotient of the observed difference between the means and the expected difference through chance (Ary et al., 2006; Gay et al., 2011). The t-test results were examined with the aim of rejecting or not rejecting a null hypothesis. According to the hypothesis of this study, it was expected that the use of PBL would positively affect performance of students in Woodwork. Therefore a directional test was performed.

3.9.2 Survey data

A survey was conducted where a questionnaire was used to establish students' attitudes towards the use of Problem-Based Learning. The questionnaire had two sections as shown in appendix 4. Section A contained items about demographic data of the subjects of the study. Section B intended to find out students' views on the appropriateness of Problem-Based Learning. Section B also had items that sought to understand the background of students in Woodwork. The section had items that sought students' perceptions on the role of PBL in skills development and cognitive development. It also had items that sought to elicit students' perceptions towards effectiveness of the use of problems and groups in Problem-Based Learning. These subsections were based on the four basic elements of PBL models namely cognitive development, use of problems, use of groups and skills development. For all Likert scale survey data for the study was first checked for distribution characteristics in order to decide the kind of test to be used (Gay et al., 2011). In addition, cross tabulation was also used to show associations between students' responses in the four categories as compared to their responses in the learning preference. The data was presented using contingency tables and Chi square was used to show any significant differences in the association.

3.10 Reliability

In research, people are concerned with the consistency of instruments used to gather data. Much as there is an allowance for error in research, researchers will always try as much as they can, to minimise errors because such errors might have an effect on the study. Reliability is the degree of certainty that an instrument will produce the same response (Ary et al., 2006). As a way of ensuring reliability of the study, the administration of measuring instrument, motivation and interest of individuals being measured were checked for.

3.11 Validity

In developing of measuring instruments, validity is the most important aspect in research. Ary et al. (2006) define validity as the ability of an instrument to measure what it was intended to measure. They further claim that validity should not only be confined to the instruments used to collect data but must also be concerned with the interpretation of the data collected using those instruments. Thus, Ary et al. (2006), add another dimension to the definition by defining validity as the availability of evidence and theory that supports the interpretation of the collected data. In other words, collecting data is one thing and interpreting the data is a different thing altogether. Consequently, much as an instrument may collect the expected data, the way in which the data is interpreted must be of more concern to the study.

In experimental design, issues of validity may arise due to a number of factors such as history, sampling and selection, instrumentation, experimental effect and subject effect. These factors mainly concern the internal validity of the experimental design (McMillan & Schumacher, 2010). As a way of reducing the threats to internal validity, all unplanned events that may come in as the study progressed were checked against. McMillan and Schumacher (2010) argue that these peripheral activities have the capacity to affect the results of the study.

External validity is concerned with whether the findings of the study can be generalised or not (Ary et al., 2006; McMillan & Schumacher, 2010). It assesses the cause-effect relationship replication where the study setting, measurements and subjects are changed. To minimise threats to external validity, the research used random sampling techniques in coming up with the experimental group and control group (Bonk & Cunningham, 1998). Ary et al. (2006) observe that experimental setting may affect external validity. As such, the study used carefully set

procedures for the interaction of the treatment groups with experimental setting. Ary et al. (2006) highlight the effects of pretesting the sample on external validity by pointing out that the actual population does not undergo pre-testing. Therefore, this affects the generalisation as the sample that is exposed to pre-testing might increase or decrease its sensitivity to the experimental variables. This allowed for only the generalisation of the pre-tested other than the unpre-tested (Bonk & Cunningham, 1998). However, Bonk and Cunningham's (1998) argument holds for within group experimental design. Campbell and Stanley (2015) contends that the challenges in generalisation come in when a study is comparing what he referred to as static groups. This study employed between groups strategy and therefore generalisation is possible.

3.12 Ethical considerations

Ethical considerations are a major concern in research as it guards against the violation of rights and privacy of the participant (Ary et al., 2006). They also check against putting the participants at risk if they partake in the study. This section of the research discusses the steps the study took so as not to discredit those who were involved in the research study. The study involved the implementation of an intervention so as to improve performance. As a result, the researcher was also a subject in the study as he was teaching in order to generate data (Ary et al., 2006). As such, the participants were naturally and simply in a class receiving the usual instructions. However, the participants were well informed about the nature of the study and the processes that were involved during the course of the study (Bonk & Cunningham, 1998; McMillan & Schumacher, 2010). As an educational study, human beings were used (McMillan & Schumacher, 2010). Therefore, the research considered the following ethical considerations;

- Seeking consent from The Malawi Polytechnic and the students to take part in the study.
- Explaining what the research is all about.
- No use of names in the final report.
- The views of individuals are confidential.
- The respondents shall use a code name during the debate e.g. professor x.
- Under no circumstances shall the researcher give out the names of the respondents to authority unless advised to do so by the respondents themselves.

CHAPTER FOUR

RESULTS AND FINDINGS

4.1 Chapter overview

This study was conducted to investigate the effect of PBL on students' performance in Woodwork at The Malawi Polytechnic. The study employed a pre-test-post-test experimental approach on first year students pursuing Bachelor of Technical Education (Science). The aim was to collect data in form of students' scores meant to determine if there existed a significant statistical difference between the experimental and control groups before and after an intervention was implemented. It also investigated students' perceptions towards PBL as an approach to learning of Woodwork. Survey method was employed in which a questionnaire was administered to participants to collect data. This chapter presents the findings and results of the study. The choice of the research design was based on the fact that the study involved the implementation of an intervention and an evaluation of the effect of that intervention.

The chapter is divided into three major sections. The first section discusses the demographic data of the participants. This relates to gender, age and previous school attended before joining The Malawi Polytechnic. The second section presents the results concerned with the testing of the null hypothesis through t-test of independent samples. The third section presents the findings of the study from a survey conducted to investigate students' attitude towards Problem-Based Learning.

4.2 Students' performance

The first research objective of the study was to compare the performance of students that were exposed to PBL to that of the students taught using the traditional approach. The null hypothesis to the study was that there is no significant difference in the performance between the students learning using the PBL and traditional approach $(H_0 : \mu_1 = \mu_2)$. The alternative hypothesis emanating from research objective 1 was that the students exposed to the PBL will score higher than the students learning using the traditional approach $(H_A : \mu_1 \neq \mu_2)$. To address the first research objective, data was collected using pre-test and post-test assessments. Data was then

analysed using SPSS. Specifically, t-test was used to analyse the data at a significance level of $p < 0.05$.

4.2.1 Pre-test assessment

The pre-test was meant to assess students' prior knowledge of the subject matter. It was also meant to check if there were any differences between the scores of the experimental group (PBL) and the control group (traditional approach) before the intervention ($p = 0.05$). Sixty two participants wrote the pre-test assessment. The mean score was 32.98% with a standard deviation of 11.11%. The scores for the PBL group averaged score of 31.48% with a standard deviation 10.94% while the mean score for the control group was 34.48% with a standard deviation of 11.26%. The descriptive data, based on the standard deviation, also showed that the scores for the control group are more varied than those of the experimental group though the variations were minimal to warrant any significant difference.

Results on the independent t-test for comparing students' performance when taught using PBL approach and traditional approach before an intervention and after an intervention are shown in Table 4.1.

Table 4.1: Students' performance in pre-test

Variable		**Pre-test assessment**	
		Mean	**SD**
Teaching method	**Experimental group (PBL. N=31)**	31.48	10.94
	Control group (Traditional approach. N=31)	34.48	11.26
Difference in mean		-3.00	
t-value		-1.06	
p-value		0.292	

The results in table 4.1 show that the pre-test assessment mean score was higher in the group of students which was taught using the traditional approach than the group that was taught using problem based learning approach. Further analysis show that the difference in mean score among students in pre-test assessment was insignificant ($p = 0.292$). Thus at 5% significance level, the

results reveal no significant difference in the pre-test means scores between the experimental group (Problem-Based Learning approach) and the control group (traditional approach), before an intervention was implemented.

4.2.2 First post-test assessment

First post-test assessment was done midway through the semester to check for statistical significance between the experimental group and control group after an intervention was implemented. Result for the first post-test indicates that the average score was 48.91% with a standard deviation of 12.55%. Table 4.2 shows a summary of the results of the post-test.

Table 4.2: Students' performance in first post-test

Variable		**Post-test assessment 1**	
		Mean	**SD**
Teaching method	**Experimental group (Problem-Based Learning. N=31)**	54.42	11.46
	Control group (Traditional approach. N=31)	43.42	11.25
Difference in mean		11.00	
t-value		3.814	
p-value		0.000	

The results in Table 4.2 show that the students who learnt using the PBL had a mean score of 54.42% with a standard deviation of 11.46% while the students who learnt using the tradition approach had an average score of 43.42% with a standard deviation of 11.25%. Results of the first post-test assessment also show that the mean test score is higher in the group of students taught using problem based approach (54.42) than in the group taught using traditional approach (43.42). The student's first post-test mean score is 11 points higher in the experimental group than the control group when the intervention is implemented. In addition, the variation in the scores for the experimental group (SD = 11.46) is almost the same as that of the control group (SD = 11.24). Further analysis also revealed that the first post-test assessment mean scores difference is significant (p = 0.000). We, therefore, fail to accept the null hypothesis. Thus we

accept the alternative hypothesis that the students who learnt using the PBL performed better than those who were learning using the traditional method.

4.2.3 Analysis of variance of gains from pre-test to first post-test

Analysis of variance of gains scores (change in the scores between the post-test assessment and pre-test assessment) was employed to further examine the effect of the intervention (problem based approach) on the performance of students. This was employed to examine whether the mean change in the test scores from the pre-test to the first post-test is different between the problem based approach group (experimental group) and the traditional approach group (control group). The results of analysis of variance are shown in Table 4.3.

Table 4.3: Variance of gains scores between the pre-test and first post-test assessment

Variable		**Between pre-test and first post-test**		
		Mean	**SD**	**SE**
Teaching method	**Problem-Based Learning (N=31)**	22.94	11.27	2.02
	Traditional approach (N=31)	8.94	13.91	2.41
p-value		0.000		

The results of the analysis of change in scores in Table 4.3 show that there was an increase in the scores from the pre-test to the post-test for the two groups. However, the increase in the assessment scores was significantly greater for the students in the PBL approach group (Mean =22.94, SE =2.02) than the students in the traditional approach group (Mean=8.94, SE = 2.41, $F=(1,60)=18.96$, $p=0.000$).

4.2.4 Second post-test assessment

After the first post-test assessment, the groups were swapped. This means that the control group learnt using PBL in the second half of the semester while the experimental group learnt using the traditional approach in the second half of the semester. At the end of the semester, a second post-test was administered. The second post-test assessment was done to check for significant difference where the two groups swapped the learning approaches. The null hypothesis for this was that there is no significant difference in the performance of students when PBL is withdrawn

from students who had earlier learnt using Problem-Based Learning. Results for the second post-test show that the average score was 55.29% with a standard deviation of 9.53%. Table 4.4 shows results of the second post-test.

Table 4.4: Students' performance in second post-test

Variable		**Post-test assessment 2**	
		Mean	**SD**
Teaching method	**Experimental group (Traditional approach. N=31)**	56.42	9.42
	Control group (PBL. N=31)	54.16	9.67
Difference in mean		2.26	
t-value		0.931	
p-value		0.355	

The results in Table 4.4 show that the students that learnt using the traditional approach but were previously taught using the Problem Based Learning had a mean score of 56.42% with a standard deviation of 9.42% while the students who learnt using the PBL but had previously learnt using the traditional approach had an average score of 54.16% with a standard deviation of 9.67%.

The results also reveal that the second post-test assessment mean score was higher for the experimental group that was taught using the traditional approach than the control group that was taught using PBL approach. Further analysis showed that the students' second post-test assessment mean scores difference is insignificant ($t = -0.93$, $d = -2.26$, $p = 0.355$). Thus at 5% significance level, the results revealed no significant differences in the second post-test means scores between the experimental group (traditional approach) and the control group (problem based approach), after swapping the teaching strategies. The study, therefore, accepts the alternative hypothesis that students who had earlier learnt using PBL will continue to employ PBL skills and perform equally better.

4.2.5 Analysis of variance of gains from first post-test to second post-test

Analysis of variance of gains scores between the first post-test assessment and second post-test assessment was employed to further examine the effect of the intervention on the second control group on the performance of students. This was employed to examine whether the mean change in the test scores from the first post-test to the second post-test was different between the experimental group and the control group. The results of analysis of variance are shown in Table 4.5.

Table 4.5: Variance of gains scores between the first post-test and second post-test assessment

Variable		**Between first post-test and second post-test**		
		Mean	**SD**	**SE**
Teaching method	**Problem-Based Learning (N=31)**	10.74	10.30	1.85
	Traditional approach (N=31)	2	8.81	1.58
p-value		0.001		

The results of the analysis of change in scores indicate that there was an increase in the scores in the second post-test. Thus the increase in the assessment scores was significantly greater for the students in the control group (Mean =10.74, SE =1.85) than the students in the experimental group (Mean=2.00, SE = 1.58, $F=(1,60) = 12.90$, $p = 0.001$).

4.3 Item analysis

The study went further to categorise the assessment items into four levels. These levels measured different abilities of the students before and after the intervention. The abilities tested were knowledge acquisition, interpretation, application and analysis. The item analysis sought to ascertain if PBL improved students' abilities outlined herein. The subsequent sections present the findings of the item analysis for the assessments for the different abilities.

4.3.1 Effect of PBL on knowledge acquisition

This section presents the findings of the study on students' acquisition of knowledge when taught using PBL and traditional approaches. T-test was employed to check for significant difference in students' abilities for the experimental and control groups. Table 4.6 shows results of the t-test.

Table 4.6: Students' performance in knowledge acquisition

Variable		**Pre-test assessment**		**First Post-test assessment**		**Second Post-test assessment**	
		Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**
Teaching method	**PBL. (N=31)**	30.42	11.04	62.86	13.65	57.23	9.78
	Traditional approach (N=31)	32.62	10.73	54.22	14.67	56.40	13.48
Difference in mean		-2.20		8.64		0.83	
t-value		-0.795		2.400		0.278	
p-value		0.430		0.019		0.782	

Table 4.6 reveals that students who learnt using the traditional approach scored slightly higher than those who learnt using the PBL approach in knowledge acquisition in the pre-test assessment. However, further analysis of the results showed that there was no significant difference in the mean scores for the experimental and control groups (p=0.430). Thus the difference in the mean was small to suggest any significant difference in acquisition of knowledge between the two groups before the intervention.

Results of the first post-test in Table 4.6 on students' knowledge acquisition indicated that the students who learnt using PBL had a higher mean score as compared to students who learnt using the traditional approach. The results also showed a significant difference in the performance of students in knowledge acquisition between the experimental and control groups (p=0.019). This implies that PBL significantly contributed to students' acquisition of knowledge.

The second post-test results from the item analysis showed that students in the experimental groups scored slightly higher than those in the control group as seen from Table 4.6. However, the difference was small to suggest any significant difference in the performance of the two

groups (p=0.782). The study further conducted an analysis of variance of gains in scores between the pre-test and the first post-test and between the first post-test and the second post-test to establish any significant difference in the mean score difference between the experimental and control groups in acquisition of knowledge. Table 4.7 shows the results of the analysis of variance of the mean score differences.

Table 4.7: Variance of mean score in knowledge acquisition

Variable		**Between pre-test and first post-test**			**Between first post-test and second post-test**		
		Mean	**SD**	**SE**	**Mean**	**SD**	**SE**
Teaching method	**Experimental group (N=31)**	32.43	13.86	2.49	-5.63	13.24	2.38
	Control group (N=31)	21.60	16.49	2.96	2.18	18.55	3.33
p-value		0.007			0.610		

The results of the analysis of variance in the mean score difference for knowledge acquisition in Table 4.7 show an increase in the scores from the pre-test to the first post-test for the two groups. However, the increase in the test scores was higher in the experimental group as compared to the control group. The analysis also showed that there is a significant difference in the mean score differences between the two groups in knowledge acquisition (p=0.007).

The results of change in scores in acquisition of knowledge between the first post-test and second post-test in Table 4.7 portray that there was a decrease in the scores in the experimental group that had changed methods of learning from PBL in the first part of the semester to traditional approach in the second part of the semester. However, the control group recorded a slight increase in the scores from the first post-test to the second post-test. Further analysis showed that there was no significant difference in the mean score differences between the two groups (p=0.610).

4.3.2 Effect of PBL on knowledge interpretation

In this section, the study sought to examine students' ability to understand and interpret the knowledge they had acquired. It, therefore, presents the findings on the performance of students in items that were meant to assess students' ability to express their understanding of concepts learnt. Results for the experimental group and control group were compared to establish the existence of any significant difference in their performance. The results of the t-test for students' performance in understanding and interpretation of knowledge gained are shown in Table 4.8.

Table 4.8: Students' performance in understanding and interpretation of knowledge

Variable		**Pre-test assessment**		**First Post-test assessment**		**Second Post-test assessment**	
		Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**
Teaching method	**Problem-Based Learning (N=31)**	34.49	14.23	62.30	15.85	62.40	12.06
	Traditional approach (N=31)	36.97	10.91	41.47	14.50	55.39	10.83
Difference in mean		-2.48		20.83		7.01	
t-value		-0.770		5.398		2.408	
p-value		0.444		0.000		0.019	

In table 4.8, a comparison between pre-test, first post-test and second post-test on students' understanding and interpretation of knowledge was made. The results reveal that students who learnt using the traditional approach scored slightly higher than those who learnt using the PBL approach in the pre-test assessment. Further analysis of the results on students' performance on test items that measured their understanding and interpretation of concepts showed that there was no significant difference in the mean scores for the experimental and control groups (p=0.444). This meant that the difference in the mean did not show any significant difference in knowledge understanding and interpretation between the two groups before the intervention.

Results of the first post-test in Table 4.8 on students' understanding and interpretation of knowledge show that the mean score was higher for the students who learnt using PBL as compared to students who learnt using the tradition approach. The results also show a significant

difference in the performance of students between the experimental and control groups in understanding and interpretation of knowledge (p=0.000). This means that PBL significantly contributed to students' understanding and interpretation of knowledge.

The second post-test results from the item analysis on students' understanding and interpretation of knowledge indicate that students in the experimental group scored higher than those in the control group as seen from Table 4.8. Further analysis of the results show a significant difference in the performance of the two groups in test items that assessed students' understanding and interpretation of knowledge (p=0.019).

The study further conducted an analysis of change of scores between the pre-test and the first post-test and between the first post-test and the second post-test to establish any significant difference in the mean score difference between the experimental and control groups in understanding and interpretation of knowledge. Table 4.9 shows the results of the analysis of variance of the mean score differences.

Table 4.9: Variance of mean score in students' understanding and interpretation of concepts

Variable		**Between pre-test and first post-test**			**Between first post-test and second post-test**		
		Mean	**SD**	**SE**	**Mean**	**SD**	**SE**
Teaching method	**Problem-Based Learning (N=31)**	27.81	18.25	3.27	0.11	16.55	2.97
	Traditional approach (N=31)	4.49	16.44	2.95	13.93	15.95	2.86
p-value		0.000			0.001		

The results of the analysis of variance in the mean score difference for understanding and interpretation of knowledge in Table 4.9 showed an increase in the scores from the pre-test to the first post-test for the two groups. However, the increase in the test scores was higher in the experimental group as compared to the control group. The analysis also showed that there is a significant difference in the mean score differences between the two groups in understanding and interpretation of knowledge (p=0.000).

The mean score difference in the performance of students in understanding and interpretation of knowledge from the first post-test to second post-test in Table 4.9 show that there was a very small increase in the scores in the experimental group that had changed methods of learning from PBL in the first part of the semester to traditional approach in the second part of the semester. However, the control group recorded a significant increase in the scores from the first post-test to the second post-test. Further analysis showed that there was a significant difference in the mean score differences between the two groups (p=0.001).

4.3.3 Effect of PBL on knowledge application

The assessment administered had items that intended to measure students' ability to apply the knowledge gained to other situations. This section reports on the findings on the performance of students in knowledge application to different situation. The mean scores on the performance of students in knowledge application for the experimental and control groups were compared and the t-test results are shown in Table 4.10.

Table 4.10: Students' performance in knowledge application

Variable		**Pre-test assessment**		**First Post-test assessment**		**Second Post-test assessment**	
		Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**
Teaching method	**Problem-Based Learning (N=31)**	26.45	22.59	49.19	23.99	53.76	21.82
	Traditional approach (N=31)	32.58	33.86	39.25	23.09	62.37	20.17
Difference in mean		-6.13		9.94		-8.61	
t-value		-0.838		1.663		-1.612	
p-value		0.405		0.102		0.112	

Results in Table 4.10 show that the mean score for the students who learnt using the traditional approach was higher than the mean score of those who learnt using the PBL approach in knowledge application in the pre-test assessment. However, further analysis of the results show that there was no significant difference in the mean scores for the experimental and control groups (p=0.405). This implies that the difference in the mean was too small to suggest any

significant difference between the two groups before the intervention in students' ability to apply the knowledge gained to different situations.

The performance of students in the first post-test in Table 4.10 on knowledge application indicate that the students who learnt using PBL had a higher mean score as compared to students who learnt using the tradition approach. However, the difference in the mean scores between the two groups did not give any significant difference in the performance of students in knowledge application between the experimental and control groups (p=0.102).

The second post-test results from the item analysis exhibit a lower mean score for students in the experimental group that had learnt using PBL in the first part of the semester but learnt using traditional approach in the second part of the semester while the control group had a higher mean score as seen from Table 4.10. However, the difference was too small to suggest any significant difference in the performance of the two groups in knowledge application (p=0.112).

The study further conducted an analysis of variance of gains in scores between the pre-test and the first post-test and between the first post-test and the second post-test to establish any significant difference in the mean score difference between the experimental and control groups in students' ability to apply knowledge to different situations. Table 4.11 shows the results of the analysis of variance of the mean score differences.

Table 4.11: Variance of mean score in knowledge application

Variable		**Between pre-test and first post-test**			**Between first post-test and second post-test**		
		Mean	**SD**	**SE**	**Mean**	**SD**	**SE**
Teaching method	**Problem-Based Learning (N=31)**	22.74	25.34	4.55	4.57	28.69	5.15
	Traditional approach (N=31)	6.67	35.88	6.27	23.12	26.15	4.70
p-value		0.042			0.010		

Table 4.11 show an increase in the scores from the pre-test to the first post-test for the two groups in knowledge application. However, the increase in the test scores was higher in the experimental group as compared to the control group. The analysis also show that there is a significant difference in the mean score differences between the two groups in knowledge application (p=0.042).

The mean score difference in knowledge application from the first post-test to second post-test in Table 4.11 indicate a slight increase in the scores in the experimental group that had changed methods of learning from PBL in the first part of the semester to traditional approach in the second part of the semester. However, the control group recorded a significant increase in the scores from the first post-test to the second post-test. Further analysis show that there was a significant difference in the mean score differences between the two groups (p=0.010). Thus the control group improved significantly in the second part of the semester after the method of teaching was changed from traditional approach to Problem-Based Learning.

4.3.4 Effect of PBL on analytical skills

The assessments given to the students had some items that measured students' ability to analyse issues. This section, therefore, presents students' performance in their ability to carry out a detailed examination of situations, structures or elements. This examination of issues formed the basis for discussion of concept that the students had learnt based on items that measured this ability. Table 4.12 shows the t-test results on students' performance on analysis.

Table 4.12: Students' performance in analysing situations and concepts

Variable		**Pre-test assessment**		**First Post-test assessment**		**Second Post-test assessment**	
		Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**
Teaching method	**Problem-Based Learning (N=31)**	32.42	13.22	38.65	15.95	52.37	13.10
	Traditional approach (N=31)	36.29	11.62	32.49	12.69	50.85	14.07
Difference in mean		-3.87		6.16		1.52	
t-value		-1.225		1.684		0.440	
p-value		0.225		0.097		0.662	

Results in Table 4.12 show that students who learnt using the traditional approach scored slightly higher than those who learnt using the PBL approach in situation and concept analysis in the pre-test assessment. However, further analysis of the results showed that there was no significant difference in the mean scores for the experimental and control groups (p=0.225). Thus, the difference in the mean was too small to suggest any significant difference between the two groups before the intervention.

Table 4.12 indicates that, in the first post-test, the students who learnt using PBL had a higher mean score as compared to students who learnt using the traditional approach. In fact, the mean score for the control group in the first post-test was lower than the mean score in the pre-test. Further analysis of the results show no significant difference in the performance of students in concept and situation analysis between the experimental and control groups (p=0.097).

The second post-test results from the item analysis reveal that students in the experimental groups scored slightly higher than those in the experimental group as seen in Table 4.12. However, the difference was too small to suggest any significant difference in the performance of the two groups (p=0.662).

The study further conducted an analysis of variance of gains in scores between the pre-test and the first post-test and between the first post-test and the second post-test to establish any significant difference in the mean score difference between the experimental and control groups in acquisition of knowledge. Table 4.13 shows the results of the analysis of variance of the mean score differences.

Table 4.13: Variance of mean score in analysing situations and concepts

Variable		Between pre-test and first post-test			Between first post-test and second post-test		
		Mean	**SD**	**SE**	**Mean**	**SD**	**SE**
Teaching method	**Problem-Based Learning (N=31)**	6.23	16.49	2.96	13.72	17.52	3.15
	Traditional approach (N=31)	-3.80	16.23	2.92	18.36	13.74	2.47
p-value		0.019			0.250		

The results of the analysis of variance in the mean score difference for situation and concept analysis in Table 4.13 show an increase in the scores from the pre-test to the first post-test for the experimental group while there was a decrease in the scores for the control group. The results also show that there was a significant difference in the mean score differences between the two groups (p=0.007).

Table 4.13 indicates that there was an increase in the mean scores for the two groups in concept and situation analysis from the first post-test and second post-test. However, the increase in the mean score of the control group was higher than for the experimental group that had changed methods of learning from PBL in the first part of the semester to traditional approach in the second part of the semester. Further analysis show that there was no significant difference in the mean score differences between the two groups (p=0.250).

4.4 Effect size of the mean difference in students' performance

In addition to using the p-values from the t-test for students' performance when they learn using PBL and traditional approach, Cohen's d was also used with the aim of measuring the strength of the mean differences between the two groups.

The effect sizes on acquisition, interpretation and application of knowledge as well as analytical skills were reported to determine the strength of the difference in the means between the group that learnt using PBL and traditional method. The effect size of the overall performance was also reported. Table 4.14 shows the results of effect size analysis for the pre-test, first post-test and second post-test.

Table 4.14: Cohen's d values for achievement tests

	Pre-test	**First Post-test**	**Second Post-test**
Knowledge acquisition	0.2021	0.6098	0.0705
Knowledge interpretation	0.1956	1.3713	0.6116
Knowledge application	0.2130	0.4222	0.4098
Analytical skills	0.3069	0.4274	0.1118
Overall performance	0.2702	0.9687	0.2368

Results in Table 4.14 show effect size of 0.2021 for the pre-test, 0.6098 for the first post-test and 0.0705 for the second post-test. This represents a slightly above medium size effect of PBL on knowledge acquisition. With respect to knowledge interpretation, PBL students have a very large size effect, d = 1.3713, in the first post-test as compared to small size effect for pre-test, d = 0.1956, and a slightly above medium size effect, d = 0.6116, for the second post-test. Further, the results reveal slightly lower than the medium size effect in the first post-test, d = 0.4222, and second post-test, d = 0.4098 in knowledge application as compared to a small effect size for the pre-test. With respect to students' analytical skills, the study indicated an above small effect size, d = 0.3069 in the pre-test and a slightly lower that medium effect size, d = 0.42.74 for the first post-test. On the other hand, the second post-test recorded a lower than small effect size in analytical skills. Overall, the study recorded small size effect in the pre-test, d = 0.2702, and second post-test, d = 0.2368 while above large effect size was observed in the first post-test.

4.5 Students' attitude towards PBL

Research objective 2 for the study sought to investigate students' perception towards Problem-Based Learning. A Likert scale questionnaire was used to collect data in order to answer research questions arising from this objective. The questionnaire was divided into four sections based on elements involved in PBL. These included perceptions towards PBL contribution to cognitive development, use of problems, use of groups, skills development and learning preferences. All these elements sum up to students' attitude towards the use of PBL in Woodwork.

4.5.1 Students' perception on PBL's contribution towards cognitive development

This section presents the perception of students towards the contribution of PBL towards cognitive development. The section had six items and the summary of the results are presented in Figure 4.1.

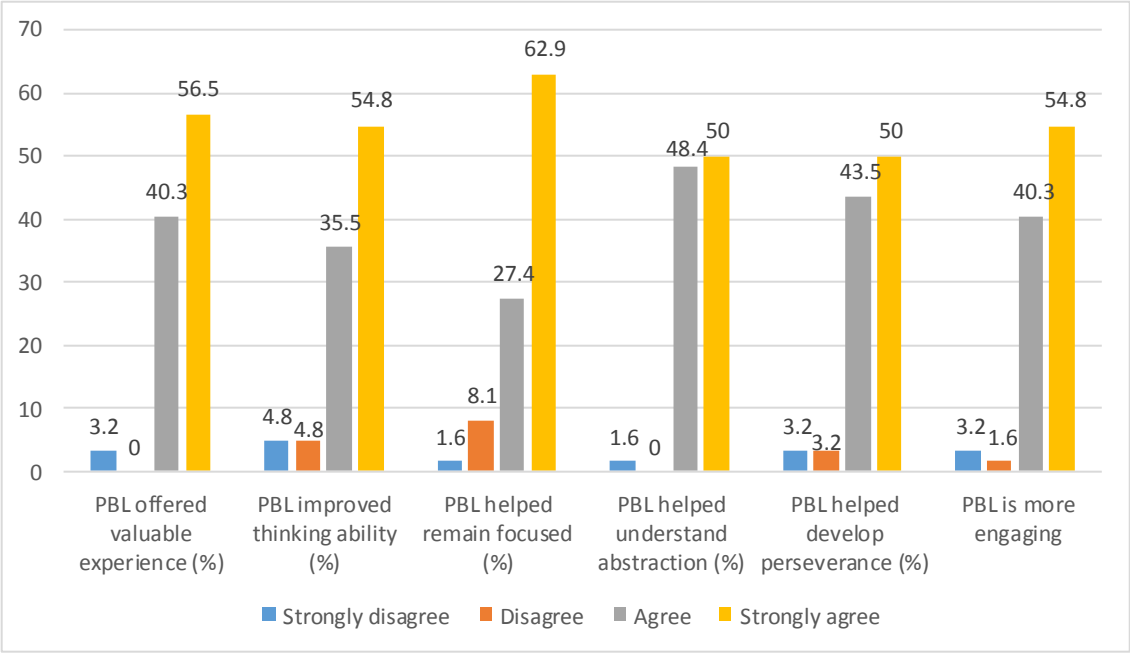

Figure 4.1: Students' perception on the use of PBL on cognitive development

Figure 4.1 presents student's perceptions on the contribution of PBL towards cognitive development in students in a woodwork class. Students' perceptions are compared across each of the statements regarding cognitive development. The graph shows that 96.8% of the students are in agreement that the PBL approach offered valuable experiences while 90.3% agreed that PBL improves thinking abilities. In addition, 90.1% hold the view that PBL helped students to remain

focused to learning and 98.4% of the participants acknowledged that PBL helped them to understand abstraction. Similarly, 93.5% indicated that their tolerance to perseverance in order to achieve set goals improved while 95.1% of the students said that PBL is more engaging. Overall, over 90% of the students have indicated that PBL contribute positively towards cognitive development.

Further analysis of the data was carried out using contingency table and chi-square test to investigate if there was a statistically significant relationship in students' perceptions on role of PBL in promoting cognitive development and preference towards Problem-Based Learning. Table 4.15 shows a table of contingency for the association between students' perception towards the role of PBL in promoting cognitive development and their preferred learning strategy.

Table 4.15: Relationship between students' perception on the role of PBL in promoting cognitive development and their learning preference

			Prefer learning through PBL		**Total**
			Disagree	**Agree**	
PBL promotes cognitive development	**Disagree**	Count	1	0	1
		Percentage	100.0%	0.0%	100.0%
	Agree	Count	7	54	61
		Percentage	11.5%	88.5%	100.0%
Total		Count	8	54	62
		Percentage	12.9%	87.1%	100.0%

	Value	**df**	**Asymp. Sig. (2-sided)**
Pearson Chi-Square	6.861a	1	0.009
Phi coefficient	0.333		

Results in Table 4.15 show that 100% of the respondents who disagreed with the point that PBL promoted cognitive development as compared to 11.5% who agreed were against learning through Problem-Based Learning. The results also indicated that none of the students who disagreed to the point that PBL promoted cognitive development as compared to 88.5% who agreed said they preferred learning using Problem-Based Learning. Statistical analysis of the

contingency table was carried out to assess the relationship between students' perception of the role of PBL in promoting cognitive development and their preferred learning strategy. The probability associated with the chi-square value of 6.861 is less than 0.05 ($p = 0.009, df = 1$). This implied the existence of an association between students' perception of the role of PBL in promoting cognitive development and their preference to learn through Problem-Based Learning.

The study further sought to check the strength of the measure of association between students' perception towards the role of PBL in promoting cognitive development and the preferred learning approach. Results of the study show a medium size effect which represent a moderately strong association between the students' perception of role of PBL towards cognitive development and preference to learn through PBL (Φ=0.333).

4.5.2 Students' perception on the role of problems in PBL

This section outlines the findings as regards the role of problems in promoting learning. Figure 4.2 shows the results of students' perception on the role of problems when using PBL approach based on five items under this category.

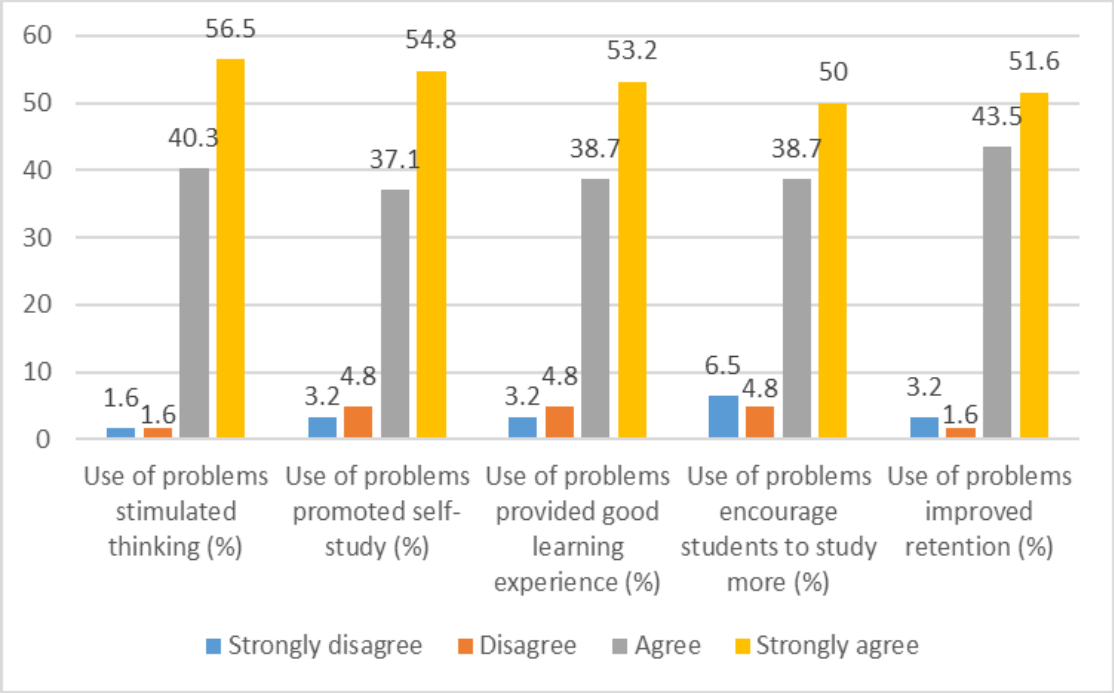

Figure 4.2: Students' perception on the role problems played in promoting learning in PBL

Students' perceptions towards use of problems in PBL are compared across each of the statements regarding the role of problems in the PBL approach. Results in figure 4.2 show that 96.8% of the students were of the view that problems stimulate thinking while 95.1% indicate that the use of problems improved students' retention. The results also indicated that 91.9% responded that PBL problems promoted independent studies as well as providing an exciting learning platform and experience. Additionally, 88.7% of the students reported that the use of problems encouraged students to spend more time studying. This means that over 85% of the students responded that use of problems promoted learning.

Further analysis of the data was conducted using chi-square test to investigate whether there was a significant relationship in students' perceptions towards the role and use of problems in PBL and preference towards Problem-Based Learning. Table 4.16 shows a contingency table for the association between students' perception towards the use of problems in PBL and their preferred learning approach.

Table 4.16: Relationship between students' perception on the role problems play in promoting learning and their learning preference

			Prefer learning through PBL		**Total**
			Disagree	**Agree**	
Use of problems improves understanding of complex concepts	**Disagree**	Count	4	3	7
		Percentage	57.1%	42.9%	100.0%
	Agree	Count	4	51	55
		Percentage	7.3%	92.7%	100.0%
Total		Count	8	54	62
		Percentage	12.9%	87.1%	100.0%

	Value	**df**	**Asymp. Sig. (2-sided)**
Pearson Chi-Square	13.742a	1	0.000
Phi coefficient	0.471		

Results in Table 4.16 show that 57.1% of the respondents who disagreed on the role of problems in PBL in promoting learning as compared to 7.3% who agree were against learning through Problem-Based Learning. Furthermore, 42.9% of the students who disagreed with the role of problems in PBL in promoting learning as compared to 92.7% who agreed recommended the use of Problem-Based Learning. The results show a chi-square value of 34.455 (p = 0.000). This shows that there is an association between students' perception on the role of PBL in improving their understanding and their preference to learn using Problem-Based Learning.

Statistical analysis on the strength of association between students' perception on the role of problems in PBL in promoting learning and their learning preference indicated a large effect size (Φ=0.471). This demonstrates that there is a strong relationship between the perception of students towards the use of groups in PBL and their preferred learning approach.

4.5.3 Students' attitudes on the effectiveness of the use of groups

Group activities form the heart of Problem-Based Learning. This section, therefore, presents data on students' perceptions on the role of groups in the learning process. Figure 4.3 provides results on students' perception towards the role of problems in a PBL class. The results are based on six items in this category.

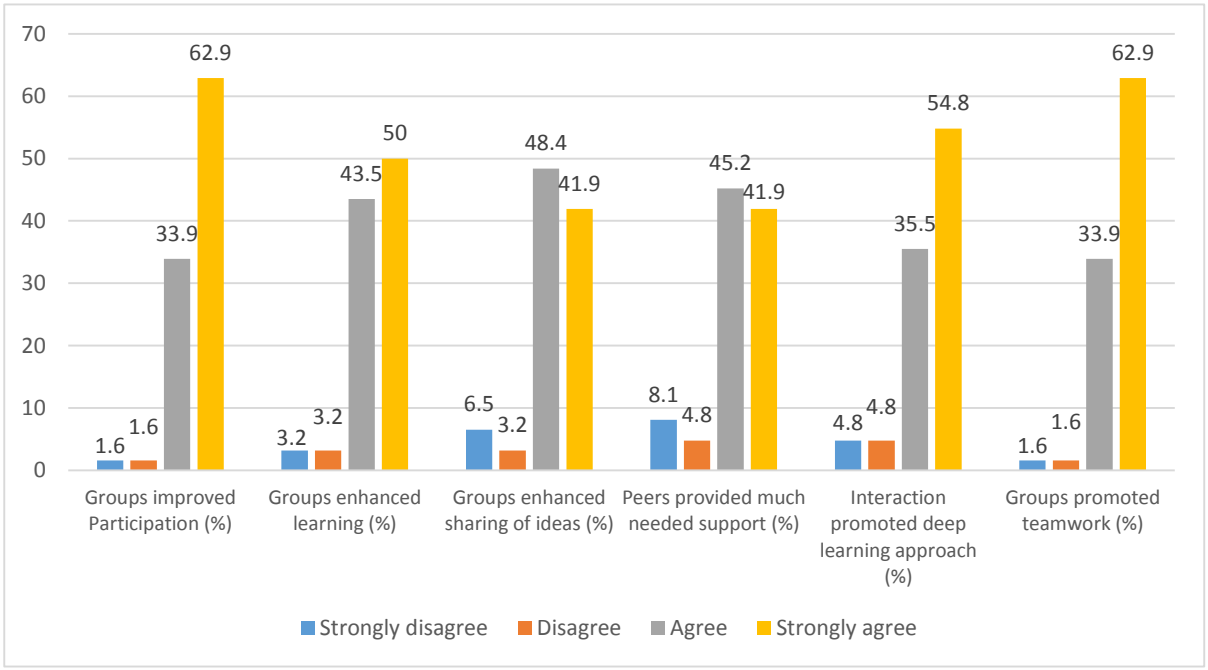

Figure 4.3: Students' perception on the use of groups in PBL

Students' perceptions towards use of groups in PBL are compared across each of the statements regarding the role of groups played in promoting learning in the PBL approach. Results in Figure 4.3 indicate that 93.5% of the students responded that group interaction enhanced learning and 87.1% argued that peers within the working groups provided the much needed support towards learning. Furthermore, 90.3% indicate that the use of groups enabled the students to freely share ideas and the interactions within the groups promoted deep approach to learning. Similarly, 96.8% of the students shared the views that groups improved students' participation as well as promoted teamwork. Thus on average, over 87% of the students consider groups important in learning.

Further analysis of the data was carried out using contingency table and chi-square test to investigate if there was a statistically significant relationship in students' perceptions towards use of groups in PBL and preference towards Problem-Based Learning. Table 4.17 shows a table of contingency for the association between students' perception towards use of small groups and their preferred learning approach.

Table 4.17: Relationship between students' perception on the role of groups in PBL and their learning preference

			Prefer learning through PBL		**Total**
			Disagree	**Agree**	
use of small groups promote learning	**Disagree**	Count	3	0	3
		Percentage	100%	0%	100%
	Agree	Count	5	54	59
		Percentage	8.5%	91.5%	100.0%
Total		Count	8	54	62
		Percentage	12.9%	87.1%	100.0%

	Value	**df**	**Asymp. Sig. (2-sided)**
Pearson Chi-Square	21.280a	1	0.000
Phi coefficient	0.586		

Results in Table 4.17 show that 100% of the respondents who strongly disagreed with the importance of use of small groups as compared to 8.5% who agreed, were against learning through Problem-Based Learning. The results also indicated that 0% of the students who disagreed with the use of groups as compared to 91.5% who agreed to the use of groups in PBL were for the use of Problem-Based Learning. Statistical analysis of the contingency table was carried out to assess the relationship between students' perception on the use of groups and their preferred learning strategy. The probability associated with the chi-square value of 21.280 is less than 0.05 (p=0.000). The results mean that there is an association between students' perception on the use of groups and their preferred learning strategy.

Phi coefficient was calculated to determine the strength of the measure of association between the students' perceptions towards the use of small groups in PBL as compared to the preferred learning approach. The study indicate a large measure of association between students' perception on the use of small groups and preference to learn through PBL (Φ=0.586).

4.5.4 Students' attitude on PBL's contribution towards skills development

The study sought to find out students' perceptions on skills that are developed and promoted when PBL is employed. Five skills were identified and formed the basis of items in this section. Figure 4.4 shows the results on skills development.

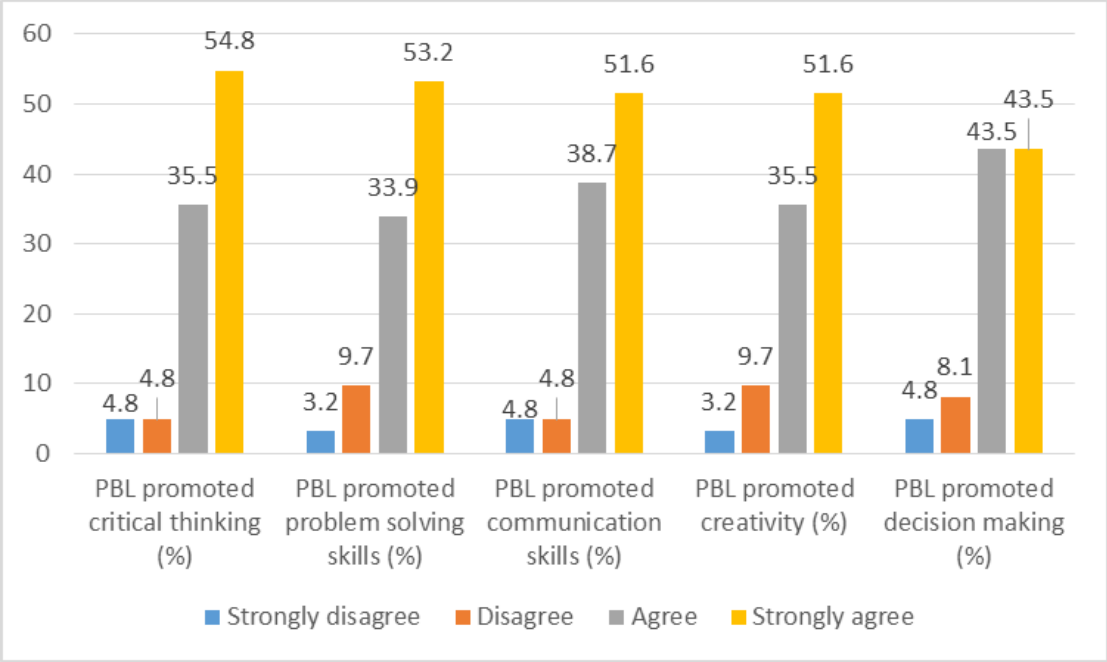

Figure 4.4: Students' perception on the use of PBL on skills development

Student's perceptions on the use of PBL and skills development are presented in figure 4.4. Student's perceptions are compared across each of the statements regarding skills development. The results in figure 4.4 showed that 90.3% of the students agreed that PBL promotes creative thinking and communication skills while 87.1% indicated that PBL promotes problem solving skills and creativity. In addition, 87% responded that PBL promoted decision making skills. Thus over 85% of the students were of the view that PBL promotes skills development in the areas discussed.

Further analysis of the data was conducted using contingency table and chi-square test to investigate if there was a statistically significant relationship in students' perceptions towards the role of PBL in promoting skills development and preference towards Problem-Based Learning. Table 4.18 shows contingency table for the association between students' perception towards use of small groups and their learning preferences.

Table 4.18: Relationship between students' perception on the role PBL in promoting skill development and their learning preference

			Prefer learning through PBL		**Total**
			Disagree	**Agree**	
PBL promotes skills development	**Disagree**	Count	6	2	8
		Percentage	75%	25%	100%
	Agree	Count	2	52	54
		Percentage	3.7%	96.3%	100.0%
Total		Count	8	54	62
		Percentage	12.9%	87.1%	100.0%

	Value	**df**	**Asymp. Sig. (2-sided)**
Pearson Chi-Square	31.516a	1	0.000
Phi coefficient	0.713		

Results of Table 4.18 show that 75% of the respondents who disagreed with the important role of PBL in promoting skills development as compared to 3.7% who agreed were against the learning through Problem-Based Learning. The results also indicate that 25% of the students who disagreed with the role of PBL in promoting skills development as compared to 96.3% who agreed supported the use of Problem-Based Learning. Statistical analysis of the contingency table was carried out to assess the relationship between students' perception on the role of PBL in promoting skills development and their preferred learning strategy. The probability associated with the chi-square value of 31.516 is less than 0.05 ($p = 0.000, df = 1$). This implies that there is an association between students' perception on the role of PBL in promoting skills development and their preference to learn using Problem-Based Learning.

The study measured the strength of association between students' perception on the role of PBL in promoting skills development and their preference to learn through PBL. The results reveal the existence of a strong association between students' perception on the role of PBL in promoting skills development and their preference to learn through Problem-Based Learning (Φ=0.713)

4.5.5 Students' learning preference

Students were then asked about their learning preference given PBL and traditional approach. The section also sums up the four elements of PBL to indicate students' attitude towards the approach. Five items were outlined as regards students' learning preferences. Figure 4.5 gives a summary of the results.

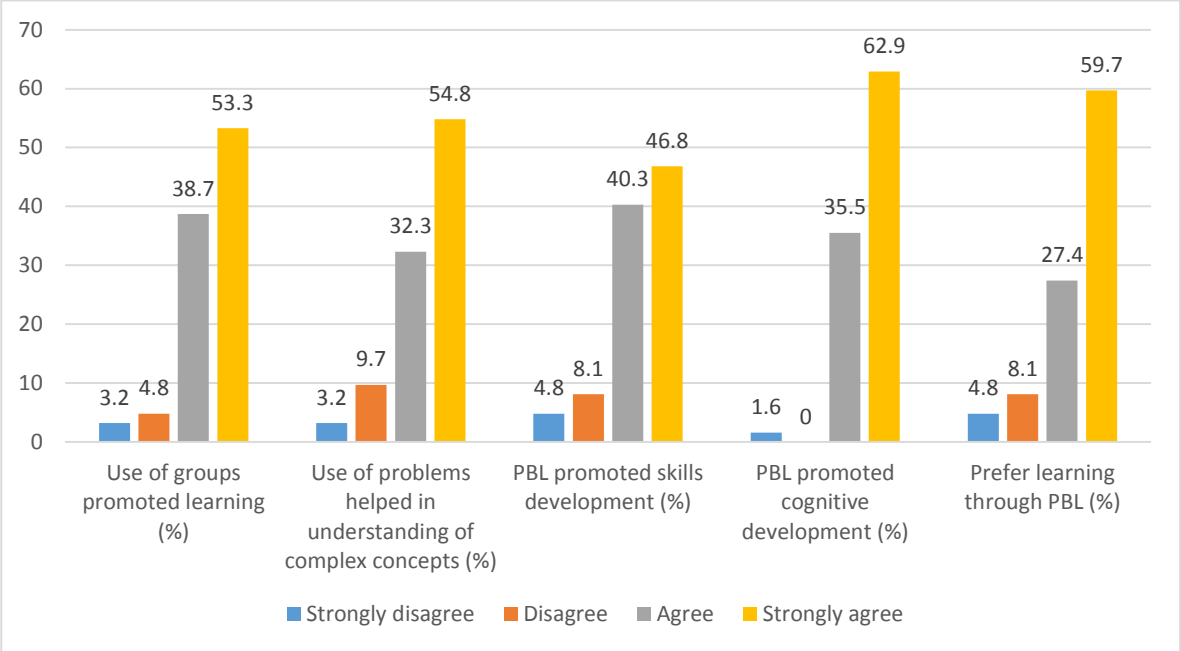

Figure 4.5: Students' learning preference

Results in figure 4.5 show that 98.4% of the students responded that PBL promotes understanding and retention of the subject matter while 91.9% upheld the view that small groups play a vital role in learning. Furthermore, 87.1% indicated that PBL promotes understanding of complex concepts and gives them a chance to practice in an environment similar to the real world. Over 87% prefer learning through PBL to traditional methods.

4.6 Chapter summary

The descriptive results of the performance in the pre-test and post-test assessment show that, generally the mean score of all the students in the post-test assessment was higher than the mean score in the pre-test assessment. There was no statistical significance in the pre-test (p=0.292) while there was statistical significance in the first post-test (p=0.000). This means that there was no difference between the experimental group and control group before the intervention. However, the experimental (PBL) group outperformed the control group (traditional approach) in the first post-test. While there was no statistical significance in the performance of the students in the second post-test (p=0.355), the analysis of variance of gain from first post-test to second post-test indicated more gains for the control group (p=0.001). Results from the attitude survey also reveal that there existed a relationship between the perception of students towards the four

elements of PBL and the students' preference to learning through PBL ($p<0.05$). The following were the key findings of the study:

1. Problem Based Learning had a positive effect on students' learning in Woodwork. The results of the study demonstrated that while there was no significant difference in the performance of students before the intervention, first post-test results show that students who learn using PBL score significantly higher.
2. When students are exposed to PBL, they tend to continue to use the PBL skills. This was evident in the second post-test results in which there was no decrease in the mean score for the experimental group after changing methods from PBL to traditional approach. In fact, the mean score for the experimental group slightly increased.

3. Problem-Based Learning improved students' acquisition of knowledge. This is demonstrated by the fact that there was no significant difference in performance of the students in the pre-test assessment on items that measured knowledge acquisition while the experimental group performed significantly well after learning using Problem-Based Learning. In addition, there was no significant difference in the second post-test assessment after the control group was also exposed to Problem-Based Learning.
4. Problem-Based Learning enhanced students' understanding of the knowledge acquired. There was a significant difference in the mean scores for items that measured students' understanding of concepts and principles after the intervention which was not the case before the intervention.
5. Problem-Based Learning improved students' ability to apply to different situation the knowledge acquired. The differences in the pre-test, first and second post-test results are insignificant. However, the mean score differences for items that measured students' ability to use the knowledge gained in different situations were significantly different for both pre-test and first post-test, and, first post-test and second post-test.
6. Problem-Based Learning enhanced students' analytical skill. Although there is no significant difference in the pre-test, first and second post-test assessments, the mean score difference indicated that PBL helped students improve their analytical skills.
7. Students had a positive perception towards the use of problems and groups to promote learning. Additionally, they also had positive perception towards the role of PBL in

promoting cognitive and skills development. Overall, the students preferred learning through PBL to traditional methods.

CHAPTER FIVE

DISCUSSION OF RESEARCH FINDINGS

5.1 Chapter overview

This study implemented an intervention to the experimental group that learnt using PBL with the aim of investigating the effect of PBL on students' performance in Woodwork. Data was collected using pre-test, first post-test and second post-test assessments. Further, attitude questionnaires were administered to collect data for students' attitude towards PBL approach. This chapter discusses these research findings. It further relates the findings of the study to existing literature in similar fields of study.

5.2 Effect of PBL on students' performance

Data was collected with the aim of accepting or rejecting the null hypotheses that:

1. There is no difference between the performance of the students who are taught using PBL and that of those taught using traditional method.
2. There is no significant difference in the performance of students when learning using PBL and after PBL is withdrawn.

Problem-Based Learning has been used in a number of fields at different educational levels for more than four decades now (Huang, 2005; Graaf & Kolmos, 2007; Neville, 2009). Data generated from studies on the effectiveness of PBL in different fields has shown varied effects of the approach on students' achievement. This study sought to investigate the effectiveness of PBL on students' performance in Woodwork. Further, the item analysis of the achievement test revealed the positive effect of PBL on students' abilities in content acquisition, knowledge interpretation, putting the knowledge acquired into use as well as the analytical skills. The findings of this study are similar to those of other authors. Wood (2003) and Ajai, Imoko and O'kwu (2013) indicate that PBL is an effective approach to teaching in medicine. Additionally, a study by Atan, Sulaiman and Idrus (2005) on the effectiveness of PBL within a web-based environment in the delivery of an undergraduate Physics course also reveal positive effects of PBL on students, performance. This study showed that the use of PBL as a learning strategy was found to enhance performance of students in Woodwork. These finding could be attributed to the manner in which PBL is implemented. The implementation of PBL is sequential and logical. As

such, students are able to acquire the basic concepts of Woodwork as well as associating their ideas and experiences to the knowledge gained. It must be noted that medical education has some similarities with Woodwork. For instance, the teaching of Woodwork, like medicine requires that students have broad knowledge base in other subject like Technical Drawing, Mathematics and Physics. Technology is changing each passing day and by the time the individuals come out of college, technology would have changed. Therefore, it is necessary to train individuals who will yearn for continued learning to keep their knowledge abreast with the prevailing situation. Problem-Based Learning has the capacity to train individuals with such qualities of life-long learning since they are exposed to self-directed learning.

In addition, Woodwork requires that students find a link between theory and practice just as the medical profession demands that students' learning must promote clinical understanding. While some individuals may have inherited ability to link theory and practice in solving real world problems, many find it difficult. In education, most scenarios used in teaching through traditional approach have not been authentic and it has been hard to discern students' abilities and such traits have not been promoted by the traditional method. It must be noted that traditional learning environments lack quality and are not stimulating as teachers and students are driven by didactic teaching that is predominated by the lecture method. The students are deprived of cognitive development due to lack of activities that promote critical thinking and independent studies. The traditional learning environment had resulted in the teachers articulating the need for students to assume responsibility of their learning yet the activities involved did not conform to the desire.

On the other hand, the use of PBL entailed that students are active participants who are always in search of information with the guide of teachers who are facilitators. This helps them to become self-directed and life-long learners. Thus, PBL has been proved to be an effective instructional approach that promotes intuitive analysis of real world problems through the use of ill-structured problem scenarios. It provided an environment in which the students were able to simulate work environment in which students practice problem solving. Thus, PBL has proven to be a successful approach to teach Woodwork students.

Other studies by Salleh, Othman, Esa, Othman, and Sulaiman (2007) and Galand, Frenay, and Raucent (2012) reveal that PBL is effective in engineering education. The students who studied using PBL in engineering education outperformed the students who studied engineering education through traditional methods. Engineering education requires that students learn essential knowledge which is prerequisite to engineering courses. This basic knowledge is meant to prepare students develop critical thinking, creative thinking and problem solving skills. In addition, the learners are required to do more research that would enable them to gather necessary information for the understanding of principles and concepts under constant supervision of experts in the field. Moreover, students in engineering education require constant practice to acquire school-to-work transition. Much as many use internship in the workplace for this purpose, PBL provided students with this opportunity whilst at school. By allowing students to practice problem solving for ill-structured scenarios, the students acquire the experience that is required to help them move from school to work.

Practice exposes the learners' weakness in particular skills and, therefore, motivates them to study hard so as to fill the skills and knowledge gaps. This in the long run enhances self-directed learning which is a critical feature of cognitive constructivism. In addition, in most cases, there are differences in the nature of machinery between those used in the industry and the school set up. Having become self-directed students while in school has helped in their school-to-work transition. While the students acquire basic and skeletal facts through independent studies and group work, the teachers provide a body of knowledge and support to help the students reconstruct knowledge. In the end, most students have been able to adapt to new situations and set up in the work place.

The study by Galand et al. (2012) concentrated on engineering student's knowledge acquisition and skills development. The study found that there was a significant difference between the performance of PBL and lecture based students. The students in the PBL group out-performed the lecture based group in knowledge acquisition. Additionally, there was a greater difference in the performance of the two groups in problem solving with the former performing exceptionally well. These studies support the findings of this study on the effectiveness of PBL approach in improving students' performance in Woodwork. Woodwork, just like engineering education falls in the construction industry in which individuals must acquire basic concepts and principles

about a subject matter, demonstrate an understanding of the same before applying the knowledge to solve problems. Thus PBL helped students to develop some skills that fostered students' learning and thereby improving their performance.

The results of this study also found that while the performance of students in the PBL and traditional approaches did not differ in knowledge acquisition in the pre-test, PBL group performed better than the traditional method group in the first pre-test. Furthermore, the mean score differences between the pre-test and the first post-test showed that much as there was gain in scores for the two groups, the gain by the PBL group was far much greater, confirming the effectiveness of PBL in enhancing knowledge acquisition in Woodwork. However, it must be noted that the analysis of variance in the mean score differences between the first post-test and the second post-test recorded a decrease in the scores in the experimental group that had now turned to use of traditional method from Problem-Based Learning. This may indicate that the withdraw of PBL affected the performance of students in knowledge acquisition. The lowering of the grade may have resulted from lack of driving force to search for knowledge that emanated from use of problems when they were learning using PBL approach in the first instance. Moreover, the use of problems in the PBL helped them to search information both in depth and breadth that resulted in knowledge acquisition and retention.

The study also indicated that the gain in scores in the control group was very low to warrant any significant difference with the experimental group between the mean score differences from the first post-test to the second post-test in knowledge acquisition. The low gain may result from the fact that the students were used to one method in the first half of the semester and it may have taken them some time to adapt to the change from traditional method to PBL unlike the experimental group which started the PBL approach fresh from holidays.

On the other hand, Galand et al.'s (2012) study reveal that PBL students outperformed LBL students in knowledge application. The study indicated that curricula differences may have contributed to the difference in the performance of students on knowledge application. This was not a surprise as Galand et al.s' (2012) findings correspond to the effect-size which are consistent with PBL curriculum characteristics. This study found no significant difference between the experimental and control group in the performance of students' knowledge application in the pre-

test, first and second post-tests. However, the analysis of variance in the mean score differences between the experimental group and control group revealed that the students who learnt using PBL had an upper hand in knowledge application than those who learnt using traditional method. Inability to find any significant difference in the t-test results despite the large differences in the performance of the students is attributed to large standard deviations that rendered that data less reliable with more students scoring towards the extreme. Based on the analysis of variance of the means differences, the experimental group that learnt using PBL in the first half of the semester had an edge over the traditional method group. Similarly, the control group performed better after switching methods from traditional method to PBL approach. The study therefore showed that PBL was also effective over the traditional method in knowledge application.

However, it must be noted that Galand et al. (2012) combined PBL and Project-Based Learning in his intervention. On the contrary, this study only used Problem-Based Learning. The question that arises now is whether results from the study by Galand et al. (2012) are due to the combination or a particular intervention. In addition, the study by Galand et al. (2012) was for four years with four cohorts. Four years must be enough to allow the learners to adopt to the new method and acquire necessary skills to fully understand and use the PBL approach. In contrast, this study was implemented within a semester, a space of four month. In addition, one group was exposed to the PBL approach for only two months, with two topics apiece. The short period has somehow affected the learners as the approaches were changed mid-way through the semester to test the second hypothesis that is discussed in the sections to come. The four cohorts produced similar effects of PBL on the performance of students indicating the replicability of the results despite changing groups in engineering education and the same could be the case in Woodwork, though another study may be required to ascertain replicability.

The findings are also similar to the meta-analysis of studies on the effect of PBL by Dochy, Segers, Bossche, and Gijbels (2003) who indicate that PBL students performed better than students in a traditional group in both knowledge acquisition and skills development. He went further to argue that students learning through PBL performed much better in problem-solving than in knowledge acquisition. The analysis of the gains in scores for the PBL groups in this study showed similar trends confirming claims by Dochy et al. (2003).

Similarly, a study by Padmavathy and Mareesh (2013) shows higher post-test performance of students in Mathematics for a group that learnt through PBL than that which learnt through lecture method. The students who learnt using PBL showed improved understanding of mathematical concepts and high ability to apply concepts. The study indicated that PBL could develop individuals who are capable of solving problems and individuals who are creative thinkers and critical decision makers. In this case, Mathematics and Woodwork requires the students to use the concepts learnt in school and apply them to the real world, making comparability between the two subjects valid. In addition, theory and practice are inseparable in the two subjects, leading to the understanding that the approaches used in one subject could have a similar effect on the other.

Liu (2005) and Larin, Buccieri, and Wessel (2010) show the success of PBL in many fields as far as knowledge and skills transfer is concerned. They pointed out improved school-to-work transition when students learn with PBL than with traditional methods. The implementation of this study on the effectiveness of PBL on students' performance in Woodwork was similar to the study by Larin et al. (2010) where the PBL approach was applied on a traditional curriculum. The results of the post-test assessments showed that PBL students had a positive learning experience as they outperformed the students who learnt using traditional approach. Implementing PBL approach on traditional curriculum may prove problematic as it requires the use of assessments that are in tandem with the context of the real-world. In PBL, there is need to engage the students so that they demonstrate their proficiencies related to their field contrary to traditional assessments which rely mostly on pen and paper examinations.

In addition, PBL requires regular feedback from both students and teachers. Lai and Tang (2000) indicate that the major challenge lies in aligning the three components within which teaching and learning operates, course objectives, teaching methods and assessment. They highlight that students had expressed dissatisfaction with the implementation of PBL within the traditional assessment systems. Biggs and Tang (2007) and East (2009) refer to this alignment as constructive alignment and results of different studies indicate varied results when PBL is implemented in a traditional assessment settings. In fact, implementing PBL in traditional assessment settings produced poor results as compared to implementing PBL within PBL curriculum.

Hung, Honassen, and Liu (2008) express displeasure with the use of traditional assessments where standardised tests are central in PBL curriculum. He argued that the traditional assessments are not in tandem with the PBL ideologies and demands. In the long run, PBL students might have been affected by such assessment protocols. The challenge presented by the traditional assessments is that it focuses on factual and conceptual knowledge only, disregarding the procedural knowledge. This makes the assessments incompatible with PBL and hence affecting the results of students and many studies. (Gijbels, Dochy, Bossche, & Segers, 2005).

In assessing the effectiveness of PBL on knowledge acquisition, this study considered a number of items depending on the concepts, principles and procedures. A study by McParland, Noble, and Livingston (2004) show that students who learnt using PBL in psychiatry performed better than those who learnt through traditional methods for both clinical examination and content knowledge. Similarly, Allen, Donham, and Bernhardt (2011) observe that PBL is an effective approach that enhances students' gain in content knowledge. However other studies have demonstrated contrary results on the effectiveness of PBL on content acquisition. For instance, studies by Tayyeb (2013) indicates that students who learnt using traditional methods outperformed PBL students in content recall tests. Allen et al. (2011) argue that the observed results on the negative effect of PBL often arise from some confusion among the adopters of PBL and those doing the analysis. Thus there are different types of PBL that may be implemented depending on a number of factors and in most cases those doing the analysis are not able to differentiate these types of Problem-Based Learning. At the same time, the adopter who are faced with time restriction tend to incorporate a great deal of traditional instructional approached within the Problem-Based Learning. Therefore, some of the criticism of PBL are misplaced.

Allen et al.s' (2011) study bemoan the tendency by instructors and lecturers to combine PBL with traditional approaches. This brings in challenges that the blended approach between the PBL and the traditional approach makes it difficult for educationists to differentiate the different PBL approaches and their effect to enhancing performance of students. In fact, Allen et al. (2011) raises fears that the resulting approaches from the blend between PBL and traditional approaches may actually be different forms of intervention altogether other than PBL itself. For instance, the

use of whole class discussion and case studies in traditional methods are sometimes mistaken to be forms of Problem-Based Learning.

Tayyeb (2013) claims that PBL promotes higher order thinking when assessing students' understanding of the relationship between concepts as well as in applying knowledge to solve problems for students in level 3. However, for level 1 students doing the same programme, the results showed that students who learnt using traditional method performed better than those who were taught using PBL as far as acquisition of content is concerned. These results are contradicting as Tayyeb (2013) argues that PBL was not effective in content acquisition for level 1 yet the students were able to apply knowledge they did not appear to have when it came to level 3. Another question that may arise in a practical subject is how can one be perceived to have achieved the required knowledge when one cannot use that knowledge? Measuring acquisition of knowledge based on recall questions alone is not enough. Contrary to the views by Tayyeb (2013) that PBL did not have an effect on acquisition of knowledge, Allen et al. (2011) acknowledge studies on PBL indicated moderate benefits on recalled content knowledge. He indicated that the staff at the school under study were satisfied with the content learning for their students learning through Problem-Based Learning. This point, in essence, refutes assertions and fears by many studies that PBL undermines the learning of essential course content. Padmavathy and Mareesh (2013) also conclude that PBL is an effective approach to teaching and learning and that it is influential in content acquisition through more interactive processes and active participation as is proposed by cognitive constructivism.

5.3 Performance of students after switching methods between the experimental and control groups

The study also sought to determine if students who were once exposed to PBL would continue to use the PBL strategies and hence maintaining their improved performance. As such, the experimental group that was initially taught using PBL for the first half of the semester learnt using the traditional approach in the second half of the semester while the control group that was initially taught using traditional approach was taught using PBL in the second half. Results of the study indicated that there was no significant difference in the performance of students between the experimental and control groups in the second post-test. According to the results of the study, there was no difference in the performance of the two groups. However, the experimental group

scored slightly higher than the control group. Despite withdrawing the intervention from the experimental group, the mean score did not fall.

The findings of this study are similar to those of Atan et al. (2005). In their study on the effectiveness of PBL on Web-based environment of an undergraduate Physics course, Atan et al. (2005) swapped the methods for the two lessons used in the study and the results showed that there was no significant difference in the performance of PBL and Content-Based Learning after swapping the approaches. Much as Atan et al. (2005) do not discuss the possible cause of the results, this study sought to explain the possible cause of the results. Rather they employed the rotational design with the sole aim of eliminating uncertainties that might have arisen from dissimilarities in the sample. In this study, the significant increase in the mean scores for the control group in the second post-test after it was exposed to PBL testifies to the effectiveness of PBL in enhancing students' performance in Woodwork. However, by maintaining higher scores despite learning through traditional approach, the experimental group demonstrated that it had mastered PBL strategies and was able to employ it even though they learnt using traditional approach. These results verify the null hypothesis that students who were once exposed to PBL continue to employ PBL strategies and that they continue to perform better.

The findings of this study are also supported by Hmelo-Silver (2004) who highlight studies by Patel, Groen and Norman which indicate that students who once used PBL tend to transfer those skills when faced with ill-structured problems, which is not the case with those students that have always used traditional methods. Problem-Based Learning requires hypothesis-driven reasoning. As such, students who were once exposed to PBL will go back to the hypothesis-driven reasoning if they come across problems in their studies. They tend to form small groups through which they hold discussions to find solutions to the problems they come across. In addition, consultations with the instructor still remain part of their studies. Kirschner, Sweller, and Clark (2006) argue that exposing students to problems through the hypothetico-deductive method presented the students with an opportunity to put into practice the skills gained. In turn the students use the same hypothetico-deductive method in other problems.

In addition, the results of the second post-test indicate that the control group improved in the performance after swapping the approaches. The tremendous improvement in the performance of the control group is a clear manifestation that group characteristics did not alter the effect of PBL

approach on students' learning of Woodwork. Hung et al. (2008) indicate that there are some human characteristics that arise from human development that might affect results of an intervention. This study did not go into details as to how the differences in these human characteristics affect the results of Problem-Based Learning. However, the results of this study, after the swapping of the approaches, were in line with the basic assumption of the study that the two groups were not different hence producing the same results.

5.4 Effect size of the mean difference in students' performance

In addition to using the p-values from the t-test for students' performance when they learn using PBL and traditional approach, Cohen's d was also used with the aim of measuring the strength of the mean differences between the two groups. Cohen (1988) proposes the standards for determining the strength of the difference in the means in Table 5.1:

Table 5.1: Cohen's d effect size standards

Effect size	Cohen's standard
0.2	Small effect
0.5	Medium effect
0.8	Large effect

However, Bloom as cited in Colliver (2000) suggests that a reasonable effect size for PBL or any other instruction intervention to be 1.0. He based the proposition on a number of studies that employed one-on-one instruction which is the most ideal approach to achieve optimal results. The one-on-one studies in different subjects produced and effect size of about 2.0. Problem-Based Learning, being an instructional approach approximate to one-on-one instruction is expected to produce a large effect size.

Problem-Based learning produced very large positive effect size on students' understanding and interpretation of knowledge. The Cohen's d value in knowledge interpretation after the intervention represents a significant difference between the experimental group and control group. This means the PBL students performed considerably higher than the traditional approach group. The effect size is consistent with the expected standards of a worthwhile intervention if compared to Bloom's suggestion. With respect to Cohen's d interpretation table (see Appendix

9), the performance of 91.51% of the students who learnt using PBL is above the mean score for the group that learnt through traditional method. Results in knowledge acquisition indicate a medium size effect for the PBL students after the intervention. The trend in knowledge application and analytical skills is also demonstrate a medium size effect that is in consistency with improved performance for the students that learnt using Problem-Based Learning. Thus, despite not showing any significant difference in the performance of PBL students in knowledge application and analysis of concepts and situations, the PBL students performed considerably better than those that learnt using traditional approach as indicated by the effect size.

It must be noted that the overall performance of the students that learnt using PBL produced the expected impact as indicated by the large effect size with 83.24% of the group performing above the mean of the control group. This is the case whether using the standards set by Cohen (1988) or Bloom as cited in Colliver (2000). Looking at particular items in question, acquisition, understanding and application of knowledge and analytical skill, the effect size was reasonable as it ranged from medium size to large. There are, for sure, a number of issues leading to the varied results on the effect size. Azer (2001) contends that change is a gradual process that takes time for people to internalise. Considering that the students who participated in the study are coming from a traditional curriculum background and have never be exposed to approaches like PBL, it may take the longer to master and perfect the requirements of the approach. In fact, Azer (2001) argues that many studies that involve implementation of PBL within a short period have produced poor results.

To this effect, the gains made by the students that studied through PBL cannot be overlooked. That is to say, the results so far are promising. Surely, if these students continue to be exposed to PBL, there is going to be continued improvement in the performance as the learners master the approach. Rather than simply learning, the students are also learning to learn. The learning to learn is the necessary element that is actually important though not measured when comparing PBL with other approaches. It is unreasonable to expect greater changes in all abilities from the onset of the intervention if we are to consider the nature of previous curricula the participants were exposed to.

5.5 Students' attitude towards PBL

Measuring attitude of students towards PBL was based on students' agreeing with statements that were grouped into different categories. These categories included cognitive development, use of problems, use of groups and skills development. Another section to sum up the learning preference was also available.

5.5.1 Perceptions towards cognitive development

The results of the study showed that students were of the view that PBL promoted their cognitive development. It was also indicated that there is a strong correlation in the students' responses between their perception towards the role of PBL in promoting cognitive development and their preference towards Problem-Based Learning.

These findings are supported by literature from other studies. Allen et al. (2011) suggest compelling evidence that systematic and sustained use of PBL promoted cognitive growth. In the analysis of the effectiveness of PBL, Allen et al. (2011) report the success of PBL in a number of studies. They indicate that methods that encourage interaction and are more engaging are superior to lecture-centred strategies as far as improving students' achievement is concerned. In his study on the effectiveness of hypermedia PBL application, Liu (2005) claims that PBL results in long-term retention of content as well as promoting higher students' motivation. It must be noted that motivation is very crucial in influencing students to learn and aim at high achievement. Motivated students tend to keep up with challenges, have higher tolerance to problems being faced and strive to perform better despite challenges (Strobel & Barneveld, 2009). Liu (2005) indicates that students who are highly motivated withstand all the challenges and sustain their efforts to learn.

A study by Padmavathy and Mareesh (2013), to test the effectiveness of PBL in teaching the concepts of Mathematics, assert that PBL is an economic means of teaching that promotes metacognition and reasoning. Review by Hung et al. (2008) on the effect of PBL on retention of content reveal that there was no significant difference in the performance of PBL students and students who learnt using traditional method when it came to short-term retention. However, the PBL students consistently outperformed the traditional method students in long-term memory

which is of paramount importance as students will be able to apply in real context the knowledge gained in their learning.

Shoenfeld (1988) and Roh (2003) observe that the limitation of traditional methods in teaching of Mathematics is giving learners what he termed as ready-made knowledge to students who do not subscribe to the ideas. As a result, the students simply imitate the techniques and procedures without any understanding of the concept and principles. Thus the element of deep approach to learning for understanding of concepts is not promoted when teaching using the traditional method. Shoenfeld (1988) further argues that creative thinking in students is stifled when they are taught of knowledge or procedural skills before conceptualization of the knowledge. There are situations in which students need to demonstrate their own understanding of concepts rather than instructing them. The necessity for students to show own understanding emphasises the positive effect of PBL on cognitive development of the students. Problem-Based Learning accords the learners an opportunity to develop skills in construction of ideas based on conceptual knowledge and experience in procedural skills. There might be some set procedures for doing some activities in wood technology. However, the learners need not be limited to narrating the procedures. Rather, they must be exposed to such procedures and allow them to critique and evaluate them for improvement.

5.5.2 Perceptions towards use of problems in PBL

The results of the study on students' perception towards the use of problems in PBL indicate that students found the use of problems in learning useful and effective. The results also show the existence of a strong correlation in the students' responses between their perception towards the use of problems in PBL in promoting learning and their preference towards Problem-Based Learning.

These findings are in line with Ahlfeldt, Mehta, and Sellnow (2005) who observed that the use of problems in PBL creates a conducive environment that enables learning. Stepien and Gallagher (1993) argue that the use of problems allows the students to deeply probe into the issues in question, in search for connections that help them solve the problem at hand. Thus with authentic problems, the students grapple with complex ill-structured problems that allowed the learners to research on relevant information to solve the problem. Additionally, Schmidt et al. (2007) claim

that use of problems in learning resulted in the arousal of students' situational interest. The interest developed, in turn, results in a drive to learn. Hung et al. (2008) argue that problems are crucial to the effectiveness of PBL curriculum. Thus, the PBL problems must be of high quality to foster learning. Problems must be designed in a way that the knowledge that the students' search matches the intended content of the curricula.

The use of problem scenarios that are loosely structured accorded students a chance to explore ideas and learn. In addition the use of real-life situations and problems in a PBL class aids in closing the gap between theory and practice. The use of problems provides a good learning environment that calls for meaningful learning through students' motivation and engaging them in deep approaches to learning. In addition, the learner-centred PBL allow for both expert guidance and peer negotiations in knowledge construction through scaffolding and group based activities. As such, students' ability to understand the concepts and principles that were covered in class were reinforced. In the long run, life-long learning which is essential for sustainable learning is promoted (Ahlfeldt et al., 2005). Problem-Based Learning does not favour memorization and skimming. It calls for critical understanding of principles and concepts. Moreover, the active participation of the learners promotes deep learning. Problem-Based Learning offered the learners with an unimpeded environment in which they are free to contribute to knowledge re-creation based on concept, principles, own experience and the social context. The use of problems in PBL gave the students an opportunity to learn in real world work situations that allowed them to retain more information as well as preparing them for the world and its challenges.

In PBL, problems are the drivers of the learning process. In this study, a problem given to the learners provided a starting point around which students developed their own learning outcomes. In trying to solve the problem at hand, students searched for new knowledge that was required. The nature of the problems was that they were open-ended and did not seek one correct solution from the learners. As such, the students required thorough understanding of the problem from which they developed hypotheses as a step towards providing solutions to the problem. In addition, ideas formulated required the learners to evaluate them before presenting their solutions to the class. This in turn promoted deep understanding of the subject matter and helped the learners to improve their knowledge retention.

With this exposure to providing solutions to problems and learning through experiential means, the students become effective problem solvers in wood technology and related courses. Students' exposure to ill-structured problems propelled them to great success in addressing challenges encountered in wood technology. For instance, challenged with lack of bending equipment in the workshop, the learners designed their own bending forms and jigs. Before they could come up with the designs, they were supposed to demonstrate that they understood wood properties and principles of wood bending. Only then were they able not only to design, but also to provide a satisfactory explanation of how the designed form would function and from what principle the design was derived. Thus the use of problems in PBL proved effective to the learners and hence their positive perception towards the use of problems to improve learning. It must be appreciated that the use of problems as a centre for learning in PBL provided the learners with an opportunity to evaluate situations, develop creative ideas after some critical thinking and provide solutions with necessary backing and explanation.

5.5.3 Perceptions towards use of groups in PBL

Results of the study on students' perception towards use of groups showed that the students liked to learn in groups as they indicated that groups improved their participation in the learning process as well as promoted teamwork. The study also found a strong correlation in the students' responses between their perception towards the use of groups and their preference towards Problem-Based Learning.

One of the most important elements in PBL is the use of small learning groups. Ahlfeldt et al. (2005) argues that groups that are small and well-coordinated by the facilitator have proved beneficial to learning. The groups assist students to strive to find solutions to problems together with the help of the facilitator. The group-based teaching technique is efficient as the facilitator guides the students without actually incorporating the traditional approaches in teaching. As the students work together to solve problems at hand, learning takes place. The individuals' experiences shared in a group form the building block of learning in Problem-Based Learning. Schmidt, Rotgans, and Yew (2011), in their review of PBL studies, conclude that PBL promotes active participation in small groups in a bid to activate prior knowledge as demanded by social

constructivist theory. Thus use of small groups helps in the amplification of students' prior knowledge and in the process enabling the acquisition of new knowledge related to the problem in question. This process facilitates deep understanding of the subject matter and results in the enhancement of long-term memory and life-long learning.

With PBL, students were required to solve problem while working in small groups. According to Coombs and Elden (2004), the use of small groups helps instructors to concentrate on helping the students how to direct their own learning. Facilitation and scaffolding in PBL represent a shift from transmitting knowledge from teachers, instructors and lecturers who are seen as experts in respective disciplines to learners taking a leading role in own learning and teachers, lecturers and instructors assuming the role of a facilitator. In other words, the use of groups in PBL helps educators to align learning with social constructivists views. Coombs and Elden (2004) acknowledge that the use of groups results in improved knowledge retention and enables the students to transfer learning to other situations.

The results of the study are also similar to findings by Huang (2005) who claims that students enjoyed interaction among themselves as well as with the teachers. It was argued that use of groups resulted in students' good-feeling of being accepted among peers and classmates. In addition, the use of groups also resulted in the learners developing research skills that allowed them to learn on their own with teachers promoting learning through intentional activities that were carried out in groups. With reference to Vygostky's Zone of Proximal Development, Applefield, Huber, and Moallen (2000) argue that when students work in small groups, they interact with peers with higher cognitive levels. These peers help in the scaffolding for those with lower cognitive levels thereby reducing the gap between the current cognitive level of some students and what they have to achieve.

5.5.4 Perceptions towards skills development

The results of the study on the perception of students on the effect of PBL on skills development indicated that students were of the view that PBL promotes skills development. The study also found that there was a strong correlation in the students' responses between their perception towards the role of PBL in promoting skills development and their preference to learn through Problem-Based Learning.

According to Mills and Treagust (2003), students at McMaster University are specifically trained in PBL with the aim of helping them develop problem solving skills. In addition, the students are also good at interpersonal skills and they become good at team-working. This, in turn, has made the students to undertake self-directed learning through Problem-Based Learning. In a study to assess the effectiveness of PBL in clinical years to improve learning of level 3 undergraduate students among medical students, Tayyeb (2013) acknowledges that the use of PBL promoted clinical reasoning and problem solving skills. Hung et al. (2008) highlight the fact that studies by Gallagher (1992), Woods (1996), Kuhn (1998) and Lohman and Finkelstein (1999) reveal that PBL is critical to enhancing problem solving skills in students. By being given problems to find solutions for, motivation for the students soared as they realised the problem at hand is their own. They are made to realise that in the world of work, problems are not objective, rather, the different views that individuals give towards solving the problems are as a result of different interpretations of the data available. As such, they need to make decisions that stand through thorough investigations and analysis, thereby developing research and decision making skills (Stepien & Gallagher, 1993). Liu (2005) acknowledges that PBL is a student-centred approach that lays emphasis on the problem solving using complex skills and targets the development of thinking skills of the higher order. Liu (2005) further argues that the activities involved in PBL approach supports the development of problem solving skills. Padmavathy and Mareesh (2013) assert that PBL is an approach that accords students an opportunity to think critically over the problem at hand and come up with innovative and creative ideas which are then communicated within small groups and peers in classroom setting.

It has been indicated in earlier discussions of this study that PBL starts with a problem. As such, the learners need to have relevant skills in analytical thinking, creative thinking and problem solving. The analytical thinking enabled the learners to evaluate situations and options, comparing and contrasting of solution as well as ordering and selecting of solutions from a pool of options. Critical thinking allowed the learners to analyse different concepts and principles in trying to explain some cause-effect relationships in wood technology. For instance, faced with a number of factors that would result in food poisoning from the use of a cutting board, the learners identified the cause of the poisoning as resulting from wood preservation after they had made a thorough analysis.

On the other hand, critical thinking required the learners to use their imagination to come up with a number of ideas for solutions. It required the learners to think outside the box and searching beyond what is obvious. At this moment, logical thinking, feasibility and reality are out of question. What is expected is fluency, flexibility and elaboration. It is unfortunate that in most cases, teachers stifle problem solving abilities in learners by simply delivering information to the learners. Barlow (2011) argues that creative thinking is critical to helping the learners undertake the problem-solving process. Problem-Based Learning accorded the learners with valuable in-depth and meaningful experience in problem solving skills. A study by Awang and Ramly (2008) reveals that PBL promoted creative thinking on students in engineering despite them complaining that the approach was demanding and difficult. This study established that students who participated had positive perception on the role of PBL in skills development including creative thinking. While Awang and Ramly's (2008) study measured the change in students creative thinking in a quasi-experiment using Tolerance Test of Creative Thinking, this study sought students' perception on the role of PBL in promoting skills development. He measured creative thinking using scores from the questionnaire in the three components of creativity, originality, fluency and flexibility. It must be noted that the problem solving is central to the development of other skills in the learners. In trying to solve problems, the learners become more critical and creative thinkers. In addition, they improve their communication skills since they have to communicate their ideas to the class as the learning continues. Moreover, evaluation and analysis of the cause-effect relationship in PBL enhances the learners' decision making skill as students base the selection of solutions on well-founded arguments.

5.5.5 Students' learning preference

The results of the attitude questionnaire show that students' perceptions towards the four elements of PBL mirrored varying attitudes towards Problem-Based Learning. Some of the respondents expressed displeasure with the use of PBL while the perception of the majority indicated that PBL was their preferred learning strategy. Despite the negative attitude by a small section of the participants, it must be noted that the real world is complex and presents numerous challenges. Problems in the world are ill-structured and there are no ready procedures to be used to find solutions to such problems. Therefore, there is still need to challenge and equip this section of students with skills match the task and take up life challenges. They need to develop non-technical skills which are necessary to help them become responsible citizens who can work

independently when faced with challenges. Much as learners would want to be exposed to direct instructions, they may not always have it as preferred. It must be noted that PBL approach aims at both preparing the students to be ready to take the real life problems that are complex and promoting life-long learning.

The results of this study are in line with findings from other similar studies. Ahlfeldt et al. (2005) indicate that the main focus of PBL is to create an enabling environment that would allow students to learn for the world of work. Being process oriented, self-direction, as well as reflection makes a significant contribution to learning in PBL approach. Problem-Based Learning promotes life-long learning by using strategies that put emphasis on students' understanding of concepts. Additionally, PBL uses strategies that call for critical thinking and collaborative working amongst the students.

In a study to determine the effect of PBL on students' perceptions towards PBL, Antepohl and Herzig (1999) assert that students had a positive attitude towards learning through PBL other than the lecture based approach. The students considered PBL to be effective to their leaning in basic pharmacology. In addition, the study found that the students claimed that PBL was an interdisciplinary approach that called them to seek additional resources and work in teams. Haghparast, Sedghizadeh, Shuler, Ferati, and Christersson (2007) evaluated the perception of students and faculty on PBL curriculum at two dental schools. The cross-sectional survey established that both the students and faculty expressed satisfaction with PBL curriculum. Worth noting is the fact that there was no significant difference in their perceptions towards PBL in spite of their geographical and cultural differences. According to Rehman, Rubab, Usmani, and Rehan (2013), PBL promotes reasoning that is essential to produce individuals who are well rounded in solving real-life problems. They added that knowledge acquisition as well as retention and application are enhanced. This makes PBL an appropriate method that accords learners with the opportunity to experience an approach that is coherent with lesson and course objective of woodwork and evaluation system.

5.6 Implications of the theoretical framework

This study investigated the effect of PBL on the performance of students. The study was grounded on social and cognitive constructivism. It must be noted that although constructivist theory has had a large influence on education practices, there has been little discussion on the link with Problem-Based Learning. This section therefore evaluates how the findings of the study auger with the theoretical framework of this study. It discusses the implication that constructivism has on PBL approach.

The results of the study show that PBL was effective in enhancing the performance of students in Woodwork. Further, it showed that students who learnt through PBL improved performed better in analytical skills, knowledge acquisition, interpretation and application. According to this study, the improved performance was mainly due to the use of problems that is central to Problem-Based Learning. Problem-Based Learning is a student-centred approach to teaching and learning in which students took an active role in the learning process. Tam (2000) argues that instruction must be viewed as guidance provided to students as they engage in a journey of exploring what the world has in offer other than simply transmission of knowledge.

Where educators claim the existence of the dire need to transmit knowledge, such process must not give the students ready-made knowledge, rather they should be exposed to situations and environment associated with the material to be learnt for them to make meaning from there and improve their understanding. This helps educators to provide an environment that is authentic and meaningful in the learning process; an environment that provides the students with opportunities for problem solving and decision making. This is in no doubt in line with the PBL approach in which a problem presented to the students forms the basis for learning. The PBL environment is good in promoting cognitive development and other non-technical skills such as critical thinking, creative thinking, decision making and communication skills as perceived by the participants of this study. Much as knowledge can be imposed on students, understanding the knowledge chiefly lies with the individual student. For students to develop a clear understanding of principles and concepts about something, it is imperative that the students be guided to construct their own knowledge based on their experience and social context.

Students had the opportunity to negotiate with peers and knowledge experts through horizontal and vertical interaction making PBL approach be in line with social constructivism which contends that knowledge construction is influenced by societal dynamics and interaction with the environment. Other than imposing information on the learners, the students were allowed to question whatever they came across and relate it to real-world challenges. The students viewed the lecturer as a facilitator whose main function is to scaffold and provide guidance as they strived to reduce the knowledge gap between their current ability and their full potential by helping them connect between concepts, procedures and experience. Kenley (1995) points out that some educators claim that some professions are fundamentally teacher-centred. The educators had made mention of professions like architecture and medicine being teacher-centred in nature since students' learning depends on the knowledge the teachers have accumulated over time (Kenley, 1995). In the understanding of these educators, placing emphasis on experience of teachers favours traditional method. However, exposing the learners to such experience is constructivist in nature and that is what is advocated for in Problem-Based Learning. It can, therefore, be argued that those who claim that some material need to be entirely delivered by a teacher simply lack creativity to turn such seemingly teacher-centred content to learner-centred methodologies. Teachers' commitment, innovativeness and creativity is of paramount importance to the implementation of constructivist approaches such as Problem-Based Learning. Lack of these results in the inability of the teachers and educationist to change.

Slavin (2003) claims that in constructivism, disequilibration is the driver to learning and conceptual development, PBL brings about this disequilibriation by use of problems for which the students must provide solutions that are backed by theory and practice. The problems provided to the students to solve, offer them the motivation to learn and at the same time accord the students the context to apply the knowledge gained. The use of problems to learn in PBL gives the learners dissatisfaction that push them to search for knowledge from which new knowledge is constructed after reflection.

Problem-Based Learning provides the learners with an environment suitable to infuse the assumptions arising from social constructivism. Self-directed learning, collaborative learning and interactive learning are all PBL elements that align it with constructivist theory. Problem-Based Learning, like many constructivist strategies encourage the students to solve ill-structured

problems using their knowledge and understanding. The students work in small groups, share ideas and use the shared knowledge to solve problems. In applying the shared knowledge, the students demonstrated their understanding of the knowledge they have constructed. Tam (2000) observes that there is a disparity between the traditional view and the constructivist view of instructional design. While those holding the traditional view of instructional design argue that learning must be externally-guided and knowledge as a possession, constructivists contend that learning must be self-guided and that knowledge must be regarded as a construction. Thus to constructivists, learning involves a process of constructing knowledge. In this constructive process, information from books, articles, is renegotiated into new knowledge through interpretation based on past experience and interaction with knowledge experts.

By allowing the students to demonstrate their understanding of concepts and principles, PBL provided an environment that matches those of constructivist views of a learner as an active participant to the reconstruction of knowledge. As in cognitive constructivism, the students are given a chance in PBL to individually interpret information and experiences before engaging in social negotiation with the peers, the community around and those considered as knowledge experts (Bodner, 1986; Glaser, 1988). The results of the study confirm Sawyer's (2004) argument that rote learning results in simple listening and recalling of the same factual matter and that it is easy for the students to lose information acquired in such a manner. On the other hand, it was demonstrated that assertion by Schmidt (1989) that PBL approach promoted establishment of relationship among prior knowledge, what is to be learnt and the learning experiences must be upheld. It is therefore deemed necessary and appropriate to adapt PBL in Woodwork as the approach has proved effective in enhancing students' achievement in test. In addition, PBL has also helped students develop skills for problem solving such as critical thinking, creative thinking and communication.

Results of the study reveal that the use of small learning groups in PBL setting augured well with social constructivist views that knowledge is a product of social negotiation. The interaction between teachers and students, and amongst students within the groups, lay a solid foundation in life-long learning in which students learn to apply concepts and principles learnt in the real world. However, learning does not take place effortlessly. Rather, individual experience, interaction with others and availability of information are key to unlocking individual's

understanding and construction of knowledge. What is critical is that PBL allowed the students to partake in activities related to ill-structured problems resembling problems locking their social context and background. This makes learning an experiential process in which students assign meanings to what is observed in the course of life (Bredo, 1994; Gredler, 1997).

The study has demonstrated that the traditional method is devoid of cross-disciplinary integration. In other words, the approach lacks an interface between day to day problems and what is taught in class. Thus there is no relevance of the content covered and the real world problems as individuals do not develop the necessary skills for them to adapt to the issues around them. Moreover, students in traditional method have even demonstrated their insufficiency in knowledge retention as they were outperformed by the PBL group. All in all, the results of the study have demonstrated that learning is indeed a product of knowledge and practice and that learning is achieved when students are internally driven to learn due to realisation that they have a knowledge gap that need to be filled.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

The chapter presents the conclusions and recommendations that are drawn from the study. It also discusses the methodological limitation of the study as well as giving direction on areas for further study.

6.1 Conclusion

The study revealed that PBL had a positive effect on students' learning in Woodwork. The performance of students in Woodwork, when exposed to PBL, has proved that the conception that students' minds are empty vessels that must be filled by some knowledge expert are not supported by this study. Likewise, much as the analogy of the mind to computer memory holds that short term and long term memory for processing and storage respectively have been useful in different areas of cognitive science, it provides little account on how human memory works (Norman, 2000). Thus in spite of the many architectural advantages computers have over the human mind, they do not match the human mind as they work on software. However, PBL works on three narrow principles of memory; the first being the activation of prior knowledge that facilitates the acquisition and processing of new knowledge. Schmidt (1989) argues that the extent to which an individual learns depends on the prior knowledge hence the need to activate prior knowledge. The activation of prior knowledge is usually promoted through the use of small groups. Secondly, the elaboration of knowledge at the time of learning enhances subsequent retrieval of knowledge. Thus use of discussions, responding to questions, note taking as well as use of knowledge to understand a problem other than being on the receiving end helps the students to elaborate the knowledge in the process of learning. Thirdly, students' ability to match content to context facilitates recall and application on knowledge. In order to achieve this, students must learn in an environment similar to where the knowledge is needed.

By implication, curriculum planning needs to take into consideration students' prior knowledge and past experiences. Lack of coordination between what is to be learnt and what students already know may prove detrimental to students learning. Failure to align the correct level of prior knowledge with the curriculum is a recipe for failure of the implementation of Problem-Based Learning. Much as the teachers, lecturers and instructors are experts in the subject matter,

curricula that are not well structured rely less on this expertise, rather, what is critical is the smooth transition from the students' current level of knowledge to the next through a well-structured curriculum with the help of the subject matter experts. It cannot be denied that it is easier to learn something one has prior knowledge about. Thus learning must involve moving with the students from what is known to the abstract through a series of interactive activities. By linking prior knowledge and new knowledge, the interest and curiosity of students are aroused. The students in turn see a sense of purpose and relevance in what they are learning.

Analysis of students' abilities in the study revealed that PBL approach improved students' acquisition, understanding, application and analysis of knowledge. Students who learnt using PBL performed better than those who learnt through traditional method in all the four abilities. Problem-Based Learning provided the students with greater opportunities to learn the subject matter through active participation and increased the students' motivation. Implementation of PBL required deliberated inclusion of activities that would arouse students' interest to learn more. The environment in which PBL is implemented must allow the students to develop problem solving skills, critical and analytical thinking through a well-structured interaction amongst students, lecturers and materials. In the end, PBL gave them a kind of experience that is new and desirable for life-long learning. This indicates that a change from traditional approach to PBL is desirable.

The study also revealed that students who had earlier learnt through PBL but had switched methods to traditional approach maintained their performance in the second post-test. The study indicated that when students are exposed to PBL, they tend to continue to use the PBL skills. Some people may question as to how students would use PBL skills when they are not learning through Problem-Based Learning. Much as use of problems is central to PBL, students who once learnt using the approach developed skills which they are now using. Students developed self-directed learning skills through learning using PBL approach. In addition, their problem solving skills improved. In solving problems, the students became better critical and creative thinkers as well as good decision makers and communicators. Furthermore, research skills of the student improved due to the need for independent studies and group work. Therefore, even after withdrawing PBL, the students were able to employ the skills they had mastered from the PBL

approach. In fact, the absence of problem scenarios after switching from PBL to traditional approach does not eliminate the skills the students developed already.

The study also revealed that students had a positive perception towards the use of problems and groups to promote learning. Additionally, they also had positive perception towards the role of PBL in promoting cognitive and skills development. Overall, the students preferred learning through PBL other than traditional methods. Students found the use of PBL to be effective hence their preference to learn through Problem-Based Learning. By adopting PBL approach in the teaching of woodwork, critical thinking, creativity, problem solving and decision making was promoted in the students. This is what is required of today's curriculum in this competitive world. The perception of students towards PBL corresponded to the positive effect of Problem-Based Learning. Thus their preference to learn through PBL was supported by the positive effect the approach had on their performance.

However, there are a number of issues to be considered before full adoption of Problem-Based Learning. For example, the principles of PBL require that a problem be presented to students for which they must find a solution and in the end learn in the relevant areas of the curriculum. Barrows (1996) outlines the four objectives of a PBL curriculum in the medical industry;

1. Structuring of knowledge for use in clinical context
2. Developing an effective clinical reasoning process
3. Developing self-directed learning skills
4. Increasing motivation for learning.

Barrows (1996) used these objectives to develop a taxonomy for the classification of PBL curricula. There are six categories of PBL curricula based on the degree of self-directedness of the learning process and the structure of the problem. Each category has three levels of self-directedness ranging from teacher-directed through partially teacher-student-directed to student-directed with the structure of problems ranging from complete case through partial problem simulation to full-problem simulation. The six categories of PBL curricula are (Barrows, 1996):

1. Lecture-based cases,
2. Case-based lectures,
3. case methods,

4. modified case-based,
5. problem-based,
6. Closed-loop problem-based.

In essence, this means that implementers of PBL are provided with a range of choice on the models of PBL depending on the nature of the educational objectives and the nature of the students (Hung et al., 2008). The challenge in most cases is that individual instructors adopt PBL and implement it on traditional curriculum (Hung et al., 2008). This makes it difficult for individual instructors to design good problems for use in PBL and usually find problems to woo support from the administration. This has resulted in PBL being considered a failure in many cases. Problem-Based Learning curriculum presents multiple demands during the implementation to both the learners and the instructors. The main challenges to the instructors is the use of standardized tests that do not test the all the competencies as required by Problem-Based Learning. In addition, it becomes an uphill task to incorporate work that cultivates and represents a real-world working environment in the traditional setting, hence instructors facing challenges when implementing PBL in a traditional curriculum. All in all, adopting PBL has proved to be a challenge in traditional school settings. It is required of teachers to make some significant changes in their approaches to teaching. Likewise, students must change the way they perceive learning and be ready to commit most of their time to the cause. Therefore, full adoption of PBL requires that school management takes necessary steps to create structures that support PBL curricula. Ribeiro and Mizukami (2005) acknowledge that PBL has produced many positive outcomes in a number of studies. However the adoption of PBL remains subject to a number of considerations by the institutions in question as regards teachers and students.

Most critics of PBL consider it as an unguided or minimally guided approach to learning (Kirschner et al., 2006). However, it must be noted that PBL offers enough scaffolding for learners and emphasizes the need for students' direct experience as well as individual studies. This is in line with the goals of progressive learner-centred philosophies of teaching and learning. Aulls (2002) indicates that for students to achieve all the intended goals, there must be a great deal of interaction between the students and the instructors. He talked of teaching content simultaneously with relevant scaffolding procedures. Thus much as the instructors will not solve the problems for the students, they will provide students with alternatives and suggest relevant sources of information for the students. This is a shift from content acquisition for memory based

assessments to understanding and application of the acquired knowledge. In fact, a review by Colliver (2000) argues that there is no statistical significance in the performance of the students that learn through PBL and conventional approach for medical students on standardized tests or instructor designed tests in year 1 and year 2. Hung et al. (2008) fault the use of traditional assessment in which standardized tests are used to assess students' acquisition of factual knowledge. He argues that this kind of assessment is not in line with PBL principles and thus tends to put PBL students at a disadvantage and, therefore they perform poorly in assessment requiring recall of factual knowledge. This calls for a shift from simple recall of facts to assessing the understanding and application of knowledge as this is what is required in the real world.

6.2 Methodological limitations

There is a common understanding by students that it is the responsibility of the teachers to provide knowledge to them. This traditional assumption may have an effect on students who may find PBL features foreign and unsuitable for them. This means that being the first time for most students to be exposed to PBL, they may have challenges to adapt to the new concept as it is considered time-consuming. The students may also find the idea of individual studies difficult to adapt in the initial phase of implementation due to lack of skills and capabilities to support the initiatives.

The study involved implementing PBL approach in a traditional curriculum. In essence, this meant that an individual teacher was involved in the designing of the problems. This is a departure from the practices in purely PBL curriculum where problems are designed by a team of experts. This ensures that the problems help students acquire the necessary content as per educational objectives. Therefore, the study recommends that a PBL curriculum be adapted and implemented to ascertain the current findings.

6.3 Recommendations

The following recommendation were made by the researcher based on the findings of the study.

6.3.1 Adoption of PBL in Woodwork and other technology studies

Implementation of PBL in programmes with integrated courses has proved to be a challenge in many cases. For instance, Mills and Treagust (2003) observe that the wholesome introduction of

PBL in engineering requires faculty cooperation, interest and integration from Mathematics, engineering, science and business and management departments. This proves to be an obstacle to fully implement PBL in engineering. Therefore, much as it is recommended from the study that PBL be adopted, this would be easier if done in phases starting with technology courses serviced by the Technical Education Department.

6.3.2 Training of lecturers

The study found that students had positive attitude towards Problem-Based Learning. In addition, PBL proved to be an effective approach to teaching of Woodwork, hence the need for adoption. However, for effective adoption of PBL, there is need that lecturers be trained on what PBL is and how to implement Problem-Based Learning. The department should take the initiative to ensure that its lecturers are properly trained before adopting the approach.

6.3.3 Increasing access to teaching and learning resources

Problem-Based Learning is resource intensive in terms of personnel, materials and time. Therefore, the administration needs to commit itself to provide material support to aid the implementation of Problem-Based Learning. Since the approach requires students to do independent studies so often, there is need for up-to-date books and reliable internet from which the students gather information for their studies. In addition, the teaching staff need to commit more time to planning and implementing of PBL lessons. Where classes are large, it may imply employing assistant lecturers to help in monitoring of students' work and progress.

6.3.4 Aligning assessment with PBL approach

It has been indicated that assessment procedures are one of the critical elements to the adoption of Problem-Based Learning. Therefore, there is need to review the curricula for technology studies to align them with principles and philosophy of PBL and assessment criteria. Assessments must be designed to measure the different types of knowledge the curriculum intends to bring out in the learners. A series of assignments are required to measure students' conceptual knowledge as well as procedural knowledge. Thus in technology studies, a shift from traditional method to PBL approach entails a shift in assessment from the traditional paper and pen based examination to assessing students' mortar skills.

6.4 Areas for further research

The results of the second hypothesis were based on results of the second post-test where the experimental group was taught using traditional approach, having previously been exposed to Problem-Based Learning. Much as the researcher informally observed the students in groups holding discussions and that the students were in constant consultation with the lecturer about some issues, this was not reported in the study as observations were not listed as part of the instruments for the study. It is therefore suggested that an observational study be carried out to ascertain the claims made by this study. The proposed study could also respond to the questions that may arise on whether the maintained good performance by the experimental group in the second post-test was due to learning through traditional approach or they really employed PBL skills developed when they previously learnt using Problem-Based Learning.

The study focused on students' general performance as well as performance in different abilities based on the test item. In addition, the study also measured students' attitudes towards the four elements of PBL and general attitudes toward Problem-Based Learning. Gender differences in the attitudes of students towards Problem-Based Learning as well as performance did not form part of the study. Therefore, another study may be carried out to determine any significant differences between male and female participants in the performance of students as well as the attitudes towards Problem-Based Learning.

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APPENDICES

Appendix 1

Request to undertake a research study in the Department of Technical Education at The Malawi Polytechnic

POLYTECHNIC

Date: 23rd October, 2015

The Principal
The Polytechnic
Private Bag 303
Chichiri, Blantyre 3.

Attention: Head of Department – Technical Education

Dear Sir/Madam,

REQUEST TO UNDERTAKE A RESEARCH STUDY IN THE DEPARTMENT OF TECHNICAL EDUCATION AT THE MALAWI POLYTECHNIC

My name is **Emmanuel Alinafe Molande**. I am a post-graduate student at the Malawi Polytechnic pursuing **Master of Science in Technical and Vocational Education** programme. As part of the requirement to the fulfilment of the programme, I am conducting a study to investigate the **"effectiveness of the use of Problem-Based Learning (PBL) in the teaching of Woodwork at the Malawi Polytechnic"**. With a lot of debate going on concerning how best a lesson must be delivered to promote cognitive development in the learners, the data collected will provide useful information as regard to the teaching of woodwork.

The study will use an experimental approach and a survey to collect data from first year students pursuing Bachelor of Science degree in Technical Education. The class will be divided into two groups, the experimental treatment and the control group, using probability sampling. The groups will be taught using different methods, the PBL approach and traditional approaches respectively. From the experimental approach I intend to use students' score to evaluate the effectiveness of the PBL approach. All the information collected will be confidential and will only be used for the purpose of this study and academic papers arising from this thesis.

I, therefore, request your esteemed office to give me permission to undertake the study. It is my expectation that the findings from the study will be useful in technical teacher training and beyond.

If you have any questions regarding the study or you need some information, you can contact me on 0888 955 640 or email me through emmanuelmolande@yahoo.com.

Yours sincerely

Emmanuel Alinafe Molande

Cc: Dr. V. K. Chikasanda
Mrs. D. Mtemang'ombe

Appendix 2

CONSENT LETTER

POLYTECHNIC

Date: 23rd October, 2015

Dear participants,

My name is **Emmanuel Alinafe Molande**. I am a post-graduate student at the Malawi Polytechnic pursuing **Master of Science in Technical and Vocational Education** programme. As part of the requirement to the fulfilment of the programme, I am conducting a study to investigate the **"effectiveness of the use of Problem Based Learning in the teaching of Woodwork at the Malawi Polytechnic"**. With a lot of debate going on concerning how best a lesson must be delivered to promote cognitive development in the learners, the data collected will provide useful information as regard to the teaching of woodwork. Note that your participation will go a long way to contribute to a better understanding of the pedagogical approach that would promote learning in woodwork.

The study will use an experimental approach and a survey to collect data from first year students pursuing Bachelor of Science degree in Technical Education. The class will be divided into two groups, the experimental treatment and the control group, using probability sampling. The groups will be taught using different methods, the PBL approach and traditional approaches respectively. From the experimental approach, I intend to use students' score to evaluate the effectiveness of the PBL approach. I, therefore, humbly invite you to participate in this study.

Your responses to the study will be anonymous. Therefore, you are not expected in any manner to include any identifying information in case of questionnaires. All the information collected will be confidential and will only be used for the purpose of this study and academic papers arising from this thesis.

If you have any questions regarding the study or you need some information, you can contact me on 0888 955 640 or email me through emmanuelmolande@yahoo.com.

I thank you for your time.

Yours sincerely

Emmanuel Alinafe Molande

Cc: Dr. V. K. Chikasanda
Mrs. D. Mtemang'ombe

Appendix 3

Consent form

I have read and fully understood the contents of the invitation letter to participate in the research study on the effectiveness of the use of Problem Based Learning in woodwork at the Malawi Polytechnic. Details of the procedure have been explained to my satisfaction. I therefore willingly consent to participate in the study. I understand that:

1. I have not been forced to participate in the study
2. I am free to withdraw from the study at any time
3. I am free to decline to answer particular questions
4. The study may not be of direct benefit to me
5. The information in the study may be published. However, the identity of the respondents will remain anonymous.

Name : _____

Signature : _____

Date : _____

In case you want to withdraw in the course of the study, you are free to do so by filling in the space below:

Name : _____

Signature : _____

Date : _____

Note: *fill the forms in duplicate*

Appendix 4

Survey Questionnaire

Dear respondent,

My name is **Emmanuel Alinafe Molande** currently pursuing **Masters of Science in Technical and Vocational Education** programme at the Malawi Polytechnic. As part of the fulfilment of my studies, I am conducting research to investigate **"the effectiveness of the use of Problem Based Learning in Woodwork at the Malawi Polytechnic"**. Please, take note that the information collected here will be used for academic purposes only. The information collected is confidential and as such, you are not required to provide your name.

Your participation is voluntary and highly appreciated.

Thank you.

Instructions:

1. Answer all questions by ticking or filling in where necessary.
2. Do not write your names on the questionnaire.

Biodata

1. Gender

1	Male	
2	Female	

2. Age

1	15-18	
2	19-22	
3	23-26	
4	27-30	

3. Nature of former school attended

1	High school	
2	National secondary	
3	Conventional secondary	
4	Community Day Secondary School	
5	Private school	

		Strongly Disagree	Disagree	Agree	Strongly Agree
Cognitive development					
4	I had valuable experience by learning through PBL				
5	My critical thinking ability has improved due to the use of PBL				

6	PBL helped me to remain focused while learning				
7	PBL helped me understand abstraction				
8	PBL helped me develop tolerance to persevere				
9	PBL is more engaging				
Use of problems					
10	The use of problems stimulates my thinking				
11	It promotes independent studies				
12	The use of Problem in PBL provided an exciting learning experience				
13	Encouraged me to spend more time studying				
14	It improves students' retention				
Group interaction					
15	Group interaction improves participation				
16	Group interactions enhanced my learning				
17	I Felt at ease to share ideas in the group				
18	Peers in the group were supportive				
19	Group interaction promotes deep approach to learning				
20	PBL promotes teamwork				
		Strongly Disagree	Disagree	Agree	Strongly Agree
Skills development					
21	The use of PBL has helped me develop critical thinking skills				
22	The use of PBL has helped me develop problem solving skills				
23	The use of PBL has helped me enhance my				

	communication skills				
24	The use of PBL has helped me develop creativity				
25	The use of PBL has helped me develop decision making skills				
Learning preferences					
26	The use of small groups in PBL has helped me learn better				
27	The use of problems helped me understand difficult and complex concepts				
28	PBL provided conducive environment for skills development				
29	PBL helps me understand and retain subject matter				
30	I prefer PBL approaches to traditional methods				

Appendix 5

Lathe Work: Problem 1

Problem description

A designer in a manufacturing company produces a design of an artefact shown in the figure below. You are expected to produce this artefact.

Guiding question

1. What machine would you use to make the artefact?
2. Make a well labelled sketch of the machine.
3. Explain how each part of the machine functions.
4. Discuss the quality of timber that would be suitable for the work.
5. There are a number of accessories that may be used in the production of the artefact. With the aid of sketches, explain the construction and use of the accessories you would use for the job.
6. Give a detailed procedure you would follow to produce the artefact.

7. Follow the procedure in 6 to produce a similar artefact.
8. Explain how you would apply finish to the artefact.

Deliverables

By the time you complete this problem, you should produce the following deliverables:

1. Written exercise
2. Turned artefact (Due Friday, 14th April, 2016)

Timeline

Introductory session	Week 2: Tuesday, 22nd March, 2016
Written Exercise	Week 4: Thursday, 7th April, 2016
Delivery of turned artefact	Week 5: Thursday, 14th April, 2016

Intended learning outcomes

By the end of this topic, you should be able to:

1. Demonstrate safety precautions in lathe work
2. Describe the principle parts of a lathe
3. Select materials for lathe work
4. Prepare materials for mounting on machines
5. Mount materials on machines
6. Select correct speeds
7. Select appropriate tools
8. Operate lathe machine – spindle turning
9. Operate lathe machine – face plate turning
10. Operate lathe machine – boring
11. Apply finishes to lathe work

Other skills

You are also expected to develop skills in:

1. Research and library usage
2. Writing, presentations and communication
3. Team work and collaboration
4. Time management

Appendix 6

Topic 4 - Fungicides and pesticides

A wood manufacturing company produced cutting boards to be used in the kitchen. It was discovered that all the households that used the cutting boards from this manufacturer showed signs and symptoms of poisoning. A chemical analysis of the cutting boards attributed the poisoning to availability of organophosphates and carbamate in the cutting boards. Discuss the possible source for the organophosphates and carbamate.

Deliverables

By the time you complete this problem, you should produce the following deliverables:

1. Written exercise (Due 20th May, 2016)

Timeline

Introductory session	Tuesday, 2nd May, 2016
Written Exercise	Thursday, 20th May, 2016

Intended learning outcomes

By the end of this topic, you should be able to:

1. Describe causes of wood deterioration
2. Select appropriate fungicides and pesticides
3. Apply fungicides and pesticides
4. Describe safety precautions associated with handling and disposing of fungicides and pesticides

Other skills

You are also expected to develop skills in

1. Research and library usage
2. Writing, presentations and communication
3. Team work and collaboration
4. Time management

Appendix 7

Wood bending and lamination

Introduction

A boat construction company is challenged with the idea of bending wood in the construction of boats. The bending of wood entails changing the grain direction while preserving the inherent strength as in a straight piece of wood. If possible, bending wood will allow the company to build boats from continuous pieces of wood. One method of bending wood is through steam bending. However, in practice, the fibres of the wood bent through this process may not conform to the bending as there is a tendency for the wood to straighten.

1. Describe the process of steam bending.
2. Discuss the challenges of steam bending.
3. Explore other methods of bending timber.
4. Select and demonstrate the correct method for a given job.
5. Design and make bending foams or templates.

Deliverables

By the time you complete this problem, you should produce the following deliverables:

1. A detailed design of a bending form or template

Timeline

Introductory session	Thursday, 26th May, 2016
Written Exercise	Thursday, 9th June, 2016

Intended learning outcomes

By the end of this topic, you should be able to:

1. Identify different methods of shaping and bending wood
2. Describe the principle to consider for effective wood bending

3. Describe the different methods of shaping and bending wood
4. Select and demonstrate the appropriate method for a job in hand

Other skills

You are also expected to develop skills in

1. Research and library usage
2. Writing, presentations and communication.
3. Team work and collaboration
4. Time management

Appendix 8

Topic 1 - Wood finish situation

Wood finishing is a very important component in woodwork. In production, it contributes almost 25% of the total cost of an artefact. Therefore, the decisions made at this stage are critical to the final product made. Develop a training manual for wood finishing to be used to train individuals in the wood working industry in order to improve the quality of wood products. The manual must help the individuals to;

1. Understand why finishes are applied to wood.
2. Understand how properties of wood and finishes themselves influence the methods and quality of finishing.
3. Select the appropriate wood finishes and methods for applying finishes to wood with specific qualities
4. Select appropriate technologies to be used in application of finishes to wood.
5. Prepare surfaces for timber finishing
6. Apply finishes using common technologies

Appendix 9

Cohen's d interpretation table

Cohen's standard	Effect size	Percentile standing/ cohen's U_3	Percentage overlap	Probability of superiority	Number needed to treat
	0.0	50	100	50	infinite
	0.1	53.98	96.01	52.82	34.3
Small	0.2	57.93	92.03	55.62	16.51
	0.3	61.79	88.08	58.4	10.63
	0.4	65.54	84.15	61.14	7.73
Medium	0.5	69.15	80.26	63.82	6.01
	0.6	72.57	76.42	66.43	4.89
	0.7	75.8	72.63	68.97	4.1
Large	0.8	78.81	68.92	71.42	3.53
	0.9	81.59	65.27	73.77	3.09
	1.0	84.13	61.71	76.02	2.76
	1.1	86.43	58.23	78.17	2.49
	1.2	88.49	54.85	80.19	2.27
Very large	1.3	90.32	51.57	82.1	2.1
	1.4	91.92	48.39	83.89	1.95
	1.5	93.32	45.33	85.56	1.84
	1.6	94.52	42.37	87.11	1.74
	1.7	95.54	39.53	88.53	1.65
	1.8	96.41	38.81	89.85	1.58
	1.9	97.13	34.21	91.04	1.53
	2.0	97.72	31.73	92.14	1.48
	2.1	98.21	29.37	93.12	1.44
	2.2	98.61	27.13	94.01	1.4
	2.3	98.93	25.01	94.81	1.37
	2.4	99.18	23.01	95.52	1.35
	2.5	99.38	21.13	96.16	1.33
	2.6	99.53	19.36	96.7	1.31
	2.7	99.65	17.7	97.19	1.3
	2.8	99.74	16.15	97.61	1.29
	2.9	99.81	14.71	97.98	1.28
	3.0	99.87	13.36	98.31	1.27

Appendix 10

Training manual

Problem Based Learning

Problem Based Learning is a student-centred learning approach that intends to give the students an opportunity to blend theory and practice. This can be achieved through research and application of the learned experiences, knowledge and skills in problem solving. The approach thus has the power to develop professional skills that are applicable to the real world of work in the learners. Problem Based Learning makes use of problems that are carefully constructed and then given to students so that they may find a solution to that problem. In most cases, the problem contains a description of events or situations that are observable and it is to be explained using some theoretical framework. Thus to provide a solution to the problem, the students must first tentatively identify a theory that may explain the event or situation. Problem Based Learning assumes that there is no one solution to a problem. Thus the solutions and the process of finding them may vary from one individual or group to another. This implies that PBL helps students discover multiple skills to problem solving.

History of Problem Based Learning

The concept of problem based learning was first used in medical education in the 1960s at McMaster University. Later, a number of medical schools like Harvard Medical School adopted the approach. Its usage has over time spread in the training of other professions. It has proved successful in different disciplines like engineering, law, business, architecture, physics and education.

PBL learning process

The students normally work in small groups that must meet at scheduled times with breaks in between to allow for individual learning on issues concerning the problem at hand. In the subsequent meeting after individual learning, the students share their views to the problem. Varying views must be taken on board and critically reflected upon. These meetings provide students an opportunity for self-evaluation on their understanding of the problem.

In all this process, the teacher must guide the students. The main task is to ensure the following:

- Stimulate discussion amongst students in the groups

- Make sure that all members of the group actively contribute in the discussions
- Give the students expert knowledge where necessary
- Assess progress made by the students

Characteristics of Problem Based Learning

PBL has the following characteristics

1. Enhances the use of a number of senses at a time through promotion of observational skills.
2. Relies heavily on the situations or experiments to promote professional practices.
3. The curriculum is designed with learning experiences that are practical to learners' field of learning and are intended to offer progressive and complex situations that promote development of skills in students.
4. Encourage collaboration amongst students to create a conducive learning environment. This is achieved through use of small groups in the brainstorming stages of the problem at hand.
5. Promotes student directed learning by controlling the students through set goals and objectives, timetabling, deciding the groups and setting learning outcomes.
6. The Learners must do independent studies based on the objectives and gather information to be used by the group to make decisions about the problem at hand. They must share information, what they have learnt and impact of what they have learnt.
7. PBL promotes reflective learning whereby students reflect on their learning experience strengths, weaknesses, challenges, deficiencies, remedies and assessment of achieved goals.

Distinctive features of PBL

1. **Team work**

   PBL relies on team work where individuals bring in their different abilities and skills to achieve a group goal. It entails a number of issues including shared decision making, shared learning exercises and organization of tasks. Thus group work exposes students to a working environment equivalent to that in the world of work. It promotes

communication, adaptation, listening skills and organization skills. Team work also promotes collaboration skills amongst the students.

2. **Analysis of situations and concepts**

   PBL encourages research by students by emphasizing on their analytical skills. Thus, students are expected to gather information on the problem in question and then do an analysis of the information. This gives the students information gathering skills and a chance to use the ideas to support their case. Thus students develop the required outcome from an analysis of the problem at hand through the information gathered during independent study.

3. **Reflection**

   PBL encourages reflection on the process used and the end product through evaluation. Students are also given a chance to reflect on learning experiences they undergo during the problem solving process. Reflection promotes peer and self-assessment.

4. **Assessment in PBL**

   Assessment drives the learning process especially when it is well aligned with goals of the programme. Therefore, it is required that assessment in PBL test both conceptual and procedural knowledge to match PBL philosophy. Previous studies show more usage of modified essay questions (MEQs) in PBL assessment. However PBL requires that students be assessed on their practical abilities too as it is argued that knowing the procedure is one thing and using the procedure in a practical exercise is a different thing altogether.

5. **Students are responsible for their own learning**

   PBL encourages students to bring out what they know and search for information on what they need to know. This results in increased ownership of the learning by the students. This implies that in trying to find a solution a problem, students take up the responsibility of searching and bring information to the group. However, the teacher must assess the process and the knowledge, as PBL is both knowledge and process based.

Misconceptions about PBL

The adoption and use of PBL in different fields has resulted into many misconceptions and misapplications.

i. Use of assessment methods that do not meet the PBL requirements in matching with learning outcomes.
ii. Insufficient information on nature and types of problems used (need for resources).
iii. Lack of knowledge and commitment of staff.
iv. Lack of learning resources and use of outdated learning resources.

Appendix 11

BUDGET

ACTIVITY AND REQUIREMENTS	QUANTITY	PRICE PER QUANTITY	TOTAL AMOUNT
1. PROPOSAL WRITING			
Reams of paper plain (A4)	1 Ream	K3,000.00	K 3,000.00
Printing	1 booklet	K5,600.00	K 5,600.00
Photocopying	1 booklet	K1,200.00	K 1,200.00
Binding	2 booklets	K500.00	K 1,000.00
2. DATA COLLECTION			
Transport		K20,000.00	K 20,000.00
Telephone charges	2 days	K500.00	K 1,000.00
Reams of paper plain (A4)	1 ream	K3,000.00	K 3,000.00
A4 hard covers	1	K2,500.00	K 2,500.00
Pens	1 boxes	K1,000.00	K 1,000.00
Printing	1 questionnaire	K490.00	K 490.00
Photocopying	110 copies	K105.00	K 11,550.00
3. RESEARCH REPORT			
Printing	1 booklet	K10,500.00	K 10,500.00
Photocopying	2 booklets	K2,250.00	K 4,500.00
Binding	3 booklets	K1,000.00	K 3 ,000.00
TOTAL			K 68,340.00
4. CONTINGENCY	10% of Total	10% of K 68,340.00	K 6,834.00
GRAND TOTAL			K 75,174.00

Appendix 12

Time line for research activities

Research activity	Project months (2015 – 2016)																	
	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Proposal writing	√	√	√	√	√	√												
Proposal presentation							√											
Data collection										√	√	√	√					
Data analysis														√	√			
Research finding presentation																√		
Research writing																	√	
Research presentation																		√