# PROBLEM-BASED TEACHING AND LEARNING IN SENIOR PHASE TECHNOLOGY EDUCATION IN THABO-MOFUTSANYANA DISTRICT, QWAQWA

By

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# DEDICATION

I dedicate this study to my father, Mohlabane Simon Mokoena, who is confined to his sick bed as I am submitting this piece of writing, for his love for education and to my late mother, Modiehi Julia Mokoena, for her love, motivation and encouragement during my upbringing.

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# DECLARATION

I, Matshidiso Maria Mokoena (student number 4574 3118), declare that **Problem-Based teaching and learning in senior phase technology education in Thabo Mofutsanyana District, Qwaqwa** is my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references.

Signed:…………………………..                                        Date: 07-01-2013

Mokoena, MM

# SUMMARY

## PROBLEM-BASED TEACHING AND LEARNING IN SENIOR PHASE TECHNOLOGY EDUCATION IN THABO-MOFUTSANYANA DISTRICT, QWAQWA

The aim of this study is to report findings of inquiry into the role that problem-based approach can play in the teaching and learning of Technology in Thabo-Mofutsanyana District in Qwaqwa.

This study followed qualitative research methods and ethnographic design informed by the researcher's desire for the study to be conducted from firsthand knowledge generated in the research setting. The researcher interviewed Grade 9 Technology teachers and experts, observed teaching and learning in two participating and two non-participating secondary schools in Murray & Roberts Technology Olympiad and analysed Technology teachers' lesson plans and workschedules, portfolios and files of Grade 9 Technology learners.

Key findings that this study produced include: PBL is a need in the teaching of Technology; learners function at a higher level of thinking; learners treat concepts at higher and deeper level; learners become more motivated and learners are able to discover theories and make inventions.

# KEY CONCEPTS

Problem-based learning, Constructivism, Curriculum and Assessment Policy Statement, Technology Education, Inquiry-based learning, Process skills, Critical thinking, Creative thinking, Decision-making process, Problem-solving process, Design process, Higher order thinking skills, Technology Olympiads and EXPOS.

## TABLE OF CONTENTS

## LIST OF TABLES



## LIST OF FIGURES

## LIST OF ABBREVIATIONS/ACRONYMS

Ass : Assessment Standards

C2005 : Curriculum 2005

CAPS : Curriculum and Assessment Policy Statement

DBE : Department of Basic Education

DoE : Department of Education

EMIS : Education Management and Information System

IDMEC : Investigate, Design, Make, Evaluate and Communicate

IS : Interview Schedule

LA : Learning Aim

LO : Learning Outcome

M & R : Murray and Roberts

MiniPAT : mini Practical Assessment Task

NCS : National Curriculum Statement

NS : Natural Sciences

OBE : Outcomes Based Education

OI : Oral Interview

ORT-STEP: Organisation for Educational Resources and Technology Training and Science of Technology Education Project

PBL : Problem Based Learning

P-E : Participant Expert

P-T : Participant Educator

RNCS : Revised National Curriculum Statement

SAIMechE: South African Institution of Mechanical Engineering

SDL : Self Directed Learning

SMT : School Management Team

TLA : Technology Learning Area

# CHAPTER ONE

# ORIENTATION TO THE STUDY

## 1.1 INTRODUCTION

This study aims to inquire into the role that problem-based approach can play in the teaching and learning of Technology in Thabo-Mofutsanyana Education District in Qwaqwa. When teaching is based on problem-based tasks a number of related teaching strategies can be considered. These, according to Nieman and Monyai (2006:112), include inquiry learning, problem-solving, and doing either a project or a research project. The mode of teaching that problem-based teaching and its related strategies suggest is a learner-centred one. As a learner-centred mode of teaching, problem solving helps with high order thinking (Nieman & Monyai, 2006:112). These authors further add that problem solving engages both the teacher, as learning mediator, and the learners because new discoveries emerge from such participation. Learners attach more meaning to information that they have acquired and discovered by themselves.

Solving problems by themselves instead of being told what the solution is or should be helps learners to construct knowledge in a meaningful way. New theories can be formulated because of assumptions that are confirmed or rejected by the solutions obtained (Nieman & Monyai, 2006:112). According to these authors, problem-based tasks and projects are highly motivational because of the high level of learner involvement.

According to Nieman and Monyai (2006:114), in inquiry learning the solution to the problem is not as important as the knowledge acquired of the topic under investigation and the process of inquiry. Problem solving is a type of discovery learning which, when deliberately applied, can help learners realise that the knowledge they already have may be applied in new situations, and that this process can lead to new knowledge (Killen, 1996: 98). Petty (1993: 222) adds that when well devised and managed, the discovery method offers active learning and an achievable challenge which engages learners. This author (Petty) also maintains that discovery activities motivate all but the most apathetic learners and they are very effective in developing the learners' understanding. In the discovery method, the learners use their previous knowledge and experience to develop their own understanding of the new learning. As a result, they create for themselves the important connections between new and existing learning (Petty, 1993:227). This means that the teacher should create a situation that enables the learner to see a gap or discrepancy between what they already know and any new knowledge, or what they know and what they need to know (Nieman & Monyai, 2006:114).

The nature of the Technology Learning Area (TLA) highly suggests the use of problem solving approach to teaching and learning because it contains problems and problematic situations that require a problem solving strategies. Problem solving allows learners to identify with the problem itself and thus to be in touch with the solution (Nieman & Monyai, 2006:115). Avenant (1990:117) adds that if learners are actively, thoughtfully and deeply involved in the subject matter, they are likely to understand it more easily (integration), experience it concretely (experience), exert themselves more purposefully (purposefulness and motivation), prepare more thoroughly (planning), exert themselves in accordance with their potential (individualization), teach and learn from their classmates (socialization), determine their progress towards a particular goal (evaluation), and train or drill more extensively (mastering).

Problem-based learning (PBL) offers a teaching tool that can provide an answer to meet the pedagogic demands of the 21st century. It is envisaged that this study will contribute to the practice of school teaching and the improvement of PBL effectiveness, particularly in the senior phase technology education.

Contemporary burning issues in education that relate to teaching and learning include learners who cannot make meaning of what they learn, that is learners who are not able to challenge their misconceptions, build on their preconceptions and read or write about what they have learnt. In the light of these, one of the main concerns of teachers and parent community is the decline in learners' achievement in the middle grades ('The standard of education', 2009).An area of particular concern for purposes of this studyis Technology Education where the higher level of thinking skills and problem-solving techniques are necessary for solving real-life problems.

The analysis of results in Mathematics (Maths), Natural Sciences (NS) and TLA in Thabo-Mofutsanyana District over the past three years has indicated a decline in the achievement of learners in the scores of the latter (Education Management and Information System office, Thabo-Mofutsanyana District, 2010). In fact, the analysis indicates that learners achieved the lowest scores in TLA than in Maths and NS. The analysis is presented in table 1.1 below:

**Table 1.1: 2007 - 2009 Grade 9 learners' performance in Thabo Mofutsanyana District (EMIS, 2010)**

| **Learner performance in each learning area** | **YEARS** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **2007** | | | **2008** | | | **2009** | | |
| | **Learning Areas (NS: Natural Sciences; MATHS: Mathematics; TLA: Technology Learning Area (%)** | | | | | | | | |
| | NS | MATHS | TLA | NS | MATHS | TLA | NS | MATHS | TLA |
| **Level 7** | 01 | 02 | **00** | 00 | 00 | **01** | 06 | 01 | **00** |
| **Level 6** | 03 | 09 | **01** | 02 | 01 | **00** | 18 | 04 | **01** |
| **Level 5** | 11 | 12 | **02** | 18 | 3 | **06** | 19 | 13 | **03** |
| **Level 4** | 21 | 17 | **12** | 31 | 21 | **22** | 28 | 21 | **06** |
| **Level 3** | 37 | 46 | **20** | 27 | 37 | **22** | 21 | 34 | **19** |
| **Level 2** | 20 | 9 | **26** | 19 | 34 | **70** | 6 | 17 | **29** |
| **Level 1** | 9 | 7 | **41** | 4 | 5 | **37** | 2 | 3 | **45** |
| | **Total number of learners** | | | | | | | | |
| | 15654 | | | 14716 | | | 15130 | | |

**<u>KEY</u>**

Level 7-Outstanding achievement: 80%-100%

Level 6-Meritorious achievement: 70%-79%

Level 5-Substantial achievement: 60%-69%

Level 4-Adequate achievement: 50%-59%

Level 3-Moderate achievement: 40%-49%

Level 2-Elementary achievement: 30%-39%

Level 1-Not achieved: 20%-29%

It can be observed in table 1.1, that only in 2008 did the TLA pass rate go beyond 50% for the performance level 2, i.e. to 70%. For the other years, in both performance levels 1 and 2, the pass rate was lower than 50%. It is also evident in the analysis above that the percentages started with single digits in TLA from levels 4, 5 and 6. The overall picture shows a situation that is unacceptable. The research attributes this situation mainly to teachers not tapping into PBL in their teaching, which is ideal for the teaching of Technology – Technology teaching suggests a problem-based approach.

The focus of this study is on a PBL for teaching and learning approach in Technology Education underpinned by the belief that learners are active and innovative individuals and have their own interest in and capacity for knowledge and self-development. The study also seeks to contribute to the solution about unsatisfactory learner performance in technology education evidenced above. It does this by answering the research problem that will be stated later. The background to the problem, the problem statement, aims of the study, the method of the study and the programme of the study are presented in this chapter.

## 1.2 BACKGROUND TO THE STUDY

According to Ankiewicz (1995a:248), a point in support of the introduction of Technology Education is that, as in the rest of the world, South Africa is in the midst of a recession. This has led to increasing unemployment. The author further adds that because of shortsighted policies which did not encourage the development of manpower skills in all sections of the population there exists today a critical shortage of technological expertise.

For South Africa to reach its full economic potential there must be a major increase in the number of learners entering the engineering and technology related professions to stimulate skills development, entreneurship and employment in technology. Technology Olympiad is a tool for exposing the high school learners to engineering disciplines and giving them the opportunity to enjoy technology as well as to apply their practical knowledge and skills in finding solutions through technology for real life situations (Shan, Tsuebeane, & Malherbe, 2006:95). The authors further indicate that the primary goal of the Olympiad is to bring technology awareness to as many young people as possible and to encourage them to take up professions in this field. This goal recognizes that if South Africa is to reach its full potential, there must be a major increase in the number of school leavers entering the science and technology professions. The design process is key in the completion of both EXPOS and Technology Olympiads projects. In Thabo Mofutsanyana District in particular, the Murray and Roberts Technology Olympiad project was implemented as a way to create this awareness and to encourage technology teachers to use the PBL approach in their pedagogy.

McCormick (in vanRensburg, 2008:14) states the reasons for teaching Technology as improving the economy, personal development of the individual, creating responsible citizens, political ideological reason and a mixture of the above. But the wonderment that occupies the researcher's mind has to do with the struggle that characterizes Technology Education teachers in developing their learners as envisaged technology experts. In his argument, McCormick (1990a:11) indicates that the reason for teaching Technology is one which sees educational benefits by contributing something to the development of an individual that other curriculum areas cannot. McCormick (1990a:11) further stresses his point by indicating that in the 19$^{th}$ century, when industrialists were pushing for manual training to improve the economy, teachers and other educationalists were arguing for its moral, physical, motivational and pedagogical benefits to learners. He further points out that more recently the problem-solving inherent in technology education has been seen as an educational justification. The researcher's point here is that, if the teaching of Technology is inherently based on problem-solving activities, why then arelearners at Thabo-Mofutsanyana District in Qwaqwa not able to solve problems that their teachers ask them to solve?

In his article about Technology and curriculum, McCormick (1990b:5) argues that there are four reasons for all children to study technology – the solving of real problems, reflective thinking that such problem-solving promotes, ensuring that all people are aware of technology as an important part of their culture, and that technology is important in wealth creation. These reasons are quoted to prove the point that the researcher raised in the introduction about the decline in learners' performance in Technology Education. They do not achieve the expected outcomes as envisaged. A different approach should be used to tackle this problem.

According to the Revised National Curriculum Statement (RNCS) (2002:3), (reviewed and now called Curriculum and Assessment Policy Statement), "the curriculum seeks to create a lifelong learner who is confident and independent, literate, numerate, multi-skilled, passionate, with a respect for the environment and the ability to participate in society as a critical and active citizen". The RNCS (2002:4) points out the purpose of TLA as contributing towards learners' technological literacy by giving them opportunities to develop and apply specific skills to solve technological problems; to understand the concepts and knowledge used in Technology and use them responsibly and purposefully; and to appreciate the interaction between people's values and attitudes, technology, society and the environment. Here the researcher announces with certainty that senior phaselearners at Thabo-Mofutsanyana District in Qwaqwa struggle to apply specific problem solving skills to solve technological problems. They also struggle to understand the concepts and knowledge used in Technology. That proves that they are taught in a manner which does not benefit them. These learners do not seem to receive the opportunities to develop and apply specific skills to solve technological problems. There is a need for an intervention strategy because it seems that there is a missing link in the teaching and learning of Technology. Most teachers still resort to the traditional approaches in the teaching of this new learning area. Problem-based teaching and learning can change this situation and transform the whole approach to teaching Technology.

Chapter four of the RNCS (2002:31) contains the information related to the senior phase learners. Learning Outcome 1 receives special attention in this page. Here it stresses that the design process and its associated skills of investigating, designing, making, evaluating and communicating form the backbone of the learning area should be used to structure the delivery of all the three learning outcomes in an integrated way. It is also mentioned that learners should be exposed to problems, needs or opportunities as a starting point, and that they should engage in a systematic process that allows the development of solutions that solve problems or satisfy needs. The information relates very well with the one mentioned in the Curriculum and Assessment Policy Statement (CAPS). It is crucial that the learners must be taught the associated knowledge and the skills needed to design and create a solution as they progress through a task (Department of Basic Education, 2011:9). It is further indicated that the design process (investigation, design, make, evaluate and communicate), forms the backbone of the subject and should be used to structure the delivery of all the learning aims. Learners should be exposed to problems, needs or opportunities as a starting point. They should then engage in a systematic process that allows them to develop solutions that solve problems, rectify design issues and satisfy needs (Department of Basic Education, 2011:9).This sounds like PBL approach to the researcher.

There is a point about the classroom situation having to change with regard to teaching and learning in favour of PBL. We are living in the 21st century where employers, politicians and educationists greatly demand problem-solving skills. In fact, Department of Basic Education (2010:6) declares that Technology Education was introduced into the South African curriculum in recognition of the need to produce engineers, technicians and artisans needed in modern society, and the need to develop a technologically literate population for the modern world. There has not been a time in history that the whole world (and South Africa for purposes of this study) has struggled with the solving of its technologicalproblems as it seems now. Problems are experienced in all spheres of life. Technology is supposed to be a learning area or subject that assists people to solve their problems. In fact, technology is defined as the use of knowledge, skills and resources to meet people's needs and wants by developing practical solutions to problems while considering social and environmental factors (RNCS, 2002:4; Department of Basic Education, 2010:6). Only few of these skills are evident in the Technology classrooms. Learners are still made to memorize facts. This situation should change. PBL is an approach that uses problems as contexts for learners to acquire problem-solving skills and knowledge (Uden& Beaumont, 2006). The authors further indicate that PBL describes the shift from the traditional teaching methods. They feel strongly about it that they refer to it as being more than a teaching method, but that it is a complex mixture of general teaching philosophy, learning objectives and goals.

## 1.3 MOTIVATION FOR THE STUDY

### 1.3.1 Significance of and need for the study

This study will contribute new knowledge about PBL to the senior phase teachers of Technology in Thabo-Mofutsanyana District in Qwaqwa. The change to the eight learning areas or subjects placed new teaching demands on teachers, more so that Technology Education as a relatively newcomer in the curriculum. As a result of its newness there were uncertainties regarding its implementation, especially because there were no trained teachers in the field at its rolling out in 1998.

In addition, the implementation of outcomes-based Technology Education (teaching is still influenced by the outcomes-based approach even though this has been discouraged in CAPS) has posed pedagogical challenges to teachers. For the majority of teachers in South Africa whom the Department of Education asked to volunteer to teach Technology, Technology Education is a new concept and thus a frightening one. This learning area represents a new paradigm for the majority of teachers, in that they have been used to a system which relied on rote-learning and teaching and therefore may find the shift towards a process and problem-based approach difficult.

### 1.3.2 Problem-based character of Technology Education

In the sources that the researcher has reviewed there is no clear link between Technology Education and PBL approach. The problem-based character of Technology Education is only implicated in theory, and not in practice; that is why maybe the trainings and workshops that teachers are attending are not evident in their results. In the ensuing Chapter 2 the researcher intends to indicate that there is an overwhelming evidence of PBL in OBE, and also that the relationship between the learning outcomes of TLA and the critical outcomes of C2005 confirm that problem-solving should be part of Technology Education. (Being much aware of the curriculum change, the researcher will, as part of presenting Chapter 2, offer her critical views in arguing that the principles of OBE are still embedded in the revised version of the curriculum). In practice though, teachers still apply the outdated rote-learning approaches to teach this learning area. The problem here does not lie with teachers or authors of TLA textbooks. In fact, the researcher maintains that no one is at fault here. The newness and uniqueness of TLA created challenges for curriculum implementers. This study aims to reveal the problem-based character of Technology Education as well as contribute to the discipline. In the TLA policy documents reviewed thus far, problem-based learning is related to TLA, but, there is not enough evidence on how the relationship can be put into practice. This study serves to close that gap.

### 1.3.3 Contribution of the study

The researcher maintains that this study will contribute to a better and fruitful understanding of Technology Education. The study will also add value to the teaching fraternity as teachers in the senior phase in Thabo-Mofutsanyana District in Qwaqwa (and hopefully in South Africa as a whole) will approach the TLA in a PBL approach. Technology Education is an important subject. It forms part of the educational programmes on all levels. A technological study involves learners actively in learning through thinking, doing and manufacturing. It is crucial that teachersbe able to teach it competently and learners to be able to achieve the most out of it. Technology is a way of life.

## 1.4 STATEMENT OF THE PROBLEM

Against the background provided in this chapter, and the problem that the study attempted to explore this far, a need arises to change the way Technology teachers teach Technology. This assertion triggers a research question stated as: What is the nature of the impact of problem-based learning on the teaching and learning of Technology in the senior phase schools of Thabo-Mofutsanyana District in Qwaqwa? From this main research question the following sub-questions arise:

- What is problem-based learning?
- Why is problem-based learning a need in the teaching of Technology?
- How do Technology teachers who teach learners that participate in Murray and Roberts Technology Olympiad in Thabo-Mofutsanyana District in Qwaqwa compare with the non-participants in terms of employing problem-based teaching?
- How do Technology learners who participate in Murray and Roberts Technology Olympiad in Thabo-Mofutsanyana District in Qwaqwa compare with the non-participants in terms of engaging in problem-based learning activities?

## 1.5 AIM OF THE STUDY

The main aim of this study is to investigate the nature of the impact of problem-based learning in the teaching and learning of Technology in the senior phase schools of Thabo-Mofutsanyana District in Qwaqwa. In order to achieve this aim, the following objectives should be addressed:

- To thoroughly engage in the analysis of literature on the concept of problem-based learning.
- To explore the need of problem-based learning in the teaching of Technology.

- To compare Technology teachers who teach learners that participate in Murray and Roberts Technology Olympiad in Thabo-Mofutsanyana District in Qwaqwa with their non-participant counterparts in terms of employing problem-based teaching.
- To compare Technology learners who participate in Murray and Roberts Technology Olympiad in Thabo-Mofutsanyana District in Qwaqwa with their non-participant counterparts in terms of engaging in problem-based learning activities.

## 1.6 RESEARCH DESIGN

This study follows an ethnographic research design due to the researcher's intention to interview the mentioned participants above, to observe teaching and learning in two participating schools in the Murray and Roberts Technology Olympiads and two non-participating schools, to analyse documents such as lesson plans and portfolios of Grade 9 learners who participate in the Olympiad and those who do not participate. This design is used to gain an understanding of the complexities of PBL in the teaching of Technology. Use here is made of *key informants for interviews.* It is further anticipated that here would be made of the EXPO regional coordinator in the Eastern Free State. The key informants would also be used as gatekeepers, where entrance into a certain setting is restricted or not easily accessible. The setting here may be a school (especially former model C schools), or a Murray and Roberts Technology Olympiad (especially at national level), where only the chosen few are allowed to enter.

Greef (De Vos et al., 2005:287) declare that interviewing is the predominant mode of data or information collection in qualitative research. Punch (1998:58) agrees and adds that interviewing is a very good way of accessing people's perceptions, meanings, and definitions of situations and constructions of reality. Teachers and experts would be interviewed on PBL and Technology Education so as to have an idea on their description of their experience. The unstructured one-to-one interview would be used for teachers. At the root of unstructured interviewing is an interest in understanding the experience of other people and the meaning they make of that experience. It is focused and discursive and allows the researcher and participant to explore an issue (Greef, 2005:293).

Two learners per school would be observed during their engagement in Murray and Roberts Technology Olympiads. The aim here would be to investigate the phenomenon, that is, PBL, to investigate whether the cases manifest some common characteristics and whether they are similar or dissimilar.

*Document analysis* would also be conducted. Strydom and Delport (De Vos et al., 2005:316) summarize the usefulness and value of personal documents and state that personal documents provide one with a holistic and total perspective of a person in the context of his total life. For this same reason, lesson plans of the selected teachers would be scrutinized. Also, portfolios, files and journals of Grade 9 learners would be thoroughly studied to have a better understanding as to whether PBL was at all applied, and if so, how was it applied. This includes the following documents specifically:

- Past records of Grade 9 learners who participate in Murray and Roberts Technology Olympiads and EXPOS would be studied. The records would be studied to establish the evidence of PBL in the teaching and learning of Technology.
- Lesson plans and preparation materials of teachers involved in Murray and Roberts Olympiads and EXPOS would also be studied.

### 1.6.1 Qualitative research approach

This study is aimed at investigating the effectiveness of PBL in the teaching of Technology. It is a qualitative study as the researcher deems it a recommended choice to explore answers to the nature of questions as posed. Most qualitative researchers concentrate on capturing an inside view and providing a detailed account of how those being studied understand events (Neuman, 2006:196). Also, according to Neuman (2006:196), qualitative researchers use a variety of techniques. These include interviews, participation, photographs, document studies, etc. to record their observations consistently. The qualitative approach frequently utilizes observations and in-depth interviews. Data are usually in the form of words. Johnson and Christensen (2000:20) agree with Krathwohl (1993:13) that the study begins without structure but becomes more structured as it proceeds and it also operates in a natural setting. Crowl (1996:231) adds that a qualitative approach is characterized by the following aspects:

- It takes place in a natural setting and uses the researcher as the key instrument.
- It deals with descriptive data in the form of words and pictures rather than numbers.
- It relies on inductive rather than deductive data analysis; and
- It focuses on how different people make sense of their lives.

Thus, in view of the above-mentioned statements and the perspective of the aim of the study, use would be made of the qualitative research methodology. In addition to the reason given above, this choice was made because the researcher's desire is the study to be made up of first-hand knowledge of the research setting; to avoid distancing herself from the people and events that she studies. She also wishes to be consistent in how she makes observations. That is why she opted for this methodology. The researcher also likes to consider a range of data sources and employ multiple measurement methods, as is the case with qualitative researchers. The diverse measures and interactions with different researchers are beneficial because they can illuminate different facets of a subject matter (Neuman, 2006:196).

### 1.6.2 Sample

Huysamen (2001:4) points out that it is not feasible, if not entirely impossible; to get hold of all the members of a particular population and to have them participate in the study. Sampling is part of our everyday life (Mouton, 2001:123) and all empirical research involves sampling (Punch, 2000:54). One cannot study everyone everywhere doing everything. Bless, Higson-Smith and Kagee (2006:98) define a sample as the subset of the whole population which is actually investigated by the researcher and whose characteristics will be generalized to the entire population.

Sample size depends on what one needs to know, the purpose of inquiry, what will be useful, what will have credibility and what can be done with available time and resources. The sample for this study would therefore be informed by guidelines provided by Strydom and Delport and will be made up of Grade 9 Technology Education learners and teachers who participate in the Murray and Roberts Technology Olympiad in Thabo-Mofutsanyana District in Qwaqwa. Those learners would be from two participating senior phase schools. The researcher also intended to sample one teacher from each participating school in the Robert & Murray Technology Olympiad.

A further sample would be drawn from the two non-participant senior phase schools, i.e. one Technology teacher and two learners per each of the two schools in cluster 2. Eight Technology teachers in total would suffice for this activity. Past records of the sampled learners would be studied (files and portfolios) in order to observe teaching and learning. According to Department of Basic Education (2010:6) Technology Education stimulates learners to be innovative and develops their creative and critical thinking skills. Learning Aim 1 specifies that the Technology Subject contributes towards learners' technological literacy by giving them opportunities to develop and apply specific design skills to solve technological problems. This should be evident in their portfolios and files. Finally, the participating and non-participating learners would be compared by means of a mini practical assessment task (miniPAT) that is designed according to the design process (investigating-design-make-evaluate-communicate). According to Department of Basic Education (2010:7), in all cases the teaching would be structured using the design process as the backbone for the methodology. Also, Ankiewicz (1995b:245) adds: The conclusion is reached that Technology Education can make an important contribution to South African education if the so-called 'technology process' is the major emphasis as this can be transformative and promote quality education. The miniPAT would be completed under the supervision of the researcher. An analytical rubric would be used to assess the design capability in a miniPAT.

Helpful individuals, such as the judges in EXPOS and Technology Olympiads would be interviewed so as to understand deeper about the approaches that should be followed in order to be successful in EXPOS and Technology Olympiads. Those individuals would be two district judges, two regional judges and two national judges.

### 1.6.3 Pilot study

Mouton (2001:103) says that one of the most common errors in doing research is that no piloting or pre-testing is done. Sarantakos (2000:291)adds that researchers should never start the main inquiry unless they are confident that the chosen procedures are suitable, valid, reliable, effective and free from problems and errors, or at least that they have taken all possible precautions to avoid any problems that might arise during the study. Strydom (2005:206) indicates that a pilot study commences with a literature study which puts the experience of various experts on the table. The author further adds that the prospective researcher can only hope to undertake meaningful research if he is fully up to date with existing knowledge on his prospective subject. The researcher therefore intends to undertake a lot of literature study on the teaching of Technology and PBL approach.

Strydom (2005:208) advises that the researcher should ensure that he approaches a representative number of experts whose experience and opinions he can utilize. The experts that the researcher intended to interview are the teachers from other secondary schools involved in the Murray Roberts competition other than those planned for the main interviews. The Murray Roberts Technology Olympiads organizer would be used as the verifier of my data gathering instruments for the participating schools.

By undertaking a feasibility study, the researcher can ascertain facts about the neighbourhood where the investigation would be done, for example, the accessibility of respondents, the safety of the area and whether women could be accommodated as fieldworkers (Sarantakos, 2000:293). In this regard the researcher would undertake as comprehensive and accurate an assessment as possible of the situation at schools where the main investigation would be conducted.

Testing the measuring instruments is often difficult to perform in a qualitative investigation, yet it is very important (Strydom & Delport, 2005: 332). The researcher would review lesson plans and work schedules of one teacher from participating senior phase school, and lesson plans and work-schedules of one teacher from the non-participating schools. The interview questions would be piloted as outlined in paragraph three of section 1.6.5.

After compiling the report, a discussion with participants in the pilot study would be held to get feedback about how they interpreted and understood the research instruments. This would be done in order to eliminate, inter alia, any researcher bias.

### 1.6.4 Data analysis

According to De Vos (2005:334), data analysis involves the process of making sense out of data collected by consolidating, reducing and interpreting what participants have said and what the researcher observed. Data analysis ideally starts in the process of gathering data. Transcription and analysis would be done every evening after each interview. In this way, data saturation and informational considerations would become clear as interviews progress (Greef, 2005:299). Basically, the following process would be followed in the data analysis (Leedy and Ormrod, 2005; De Vos, 2005:334):

- Organize data into smaller units in the form of main concepts, sentences and individual words.
- Peruse data several times to get a sense of what it contains as a whole. Notes suggesting categories or interpretation would be jotted down.
- Identify general categories and note the saturation point(s) as interviews continued.
- Summarize data and integrate them into text for reporting.

### 1.6.5 Validity and trustworthiness

Reliability means dependability or consistency (Neuman, 2006:196). Qualitative researchers consider a range of data sources and employ multiple measurement methods. According to Makgato (2003:210) reliability means consistency of the research instruments used to measure particular variables. Makgato (2003:210) points out that researchers evaluate reliability of instruments from different perspectives, but the basic question that cuts across various perspectives is always the same, that is, to what extent can we say that data are reliable?

Makgato (2003:211) claims that the core essence of validity is captured nicely by the word accuracy. He further points out that a researcher's data are valid to the extent that results of the measurement process are accurate. A measuring instrument is valid to the extent that it measures what it purports to measure. According to Neuman (2006:196) validity means truthful. The author further explains that qualitative researchers are more interested in authenticity than the idea of a single version of truth. Neuman (2006:196) further indicates that authenticity means giving a fair, honest, and a balanced account of social life from the viewpoint of someone who lives it every day.

To establish validity and reliability of the interview questions, the interview questions would be piloted with two key informants, three learning facilitators of TLA and five teachers who teach Technology and they would be asked to determine if the questions are appropriate. The comments forthcoming from this exercise would be taken into consideration in reshaping and finalizing the main plan for data gathering. Secondly, the researcher would follow the advice of Bless, Higson-Smith and Kagee (2006: 93), who state:

> "*The researcher must ensure that the study simulates reality as closely as possible. The conditions and situation must be seen as normal, depicting the usual reality of the participants. This means that the tests and tasks that are required of the subjects must be planned so as to minimize the whole range of reactive effects. When people behave differently due to their participation in a research project, the findings are immediately less valid than they would have been had the subjects behaved as they would on every other day of their lives*".

The aboveauthors further advise that techniques for ensuring less reactivity include making data collection as unobtrusive as possible and testing people within their usual surroundings. This is what the researcher intends to do, that is, making data collection as unobtrusive as possible by observing the participants within their usual surroundings.

## 1.7 DEFINITION OF CONCEPTS

**Technology**: According to the Department of Education (1997a:28), technology is the use of knowledge, skills and resources to meet human needs and wants, and to recognize and solve problems by investigating, designing, developing and evaluating products and systems. The Department of Education later on reviewed the definition. Thus, technology was later on defined as the use of knowledge, skills and resources to meet people's needs and wants by developing practical solutions to problems, taking social and environmental factors into consideration (Department of Education, 2002:4; Department of Basic Education, 2010:6).

**Technology Education**: Technology Education can be seen as a comprehensive experience-based educational programme that allows learners to investigate and experience the means by which people meet their needs and wants, solve problems and extend their capabilities. It is concerned with the knowledge and skills necessary to develop produce and use products or services, and how to assess the impact of these activities on humanity and the environment (Pudi, 2007:37-38). According to Department of Education (2007:2), Technology Education is an ability to solve technological problems by investigating, designing, developing, evaluating as well as communicating effectively in their own and other languages by using different modes; it is also a fundamental understanding of and ability to apply technological knowledge, skills and values, working as individuals and a group members, in a range of technology contexts. This is the definition that this study will associate with.

**Technology Olympiad**: The Technology Olympiad is a national competition for high school learners organized annually by the South African Institution of Mechanical Engineering (SAIMechE) with Murray & Roberts as its primary sponsor (Shan et al., 2006:95). The competition allows the learners to test their skills and aptitude in engineering and to apply the engineering principles they learn in class.

**Problem-based learning**: Problem-based learning is defined as a dynamic, integrative concept that engenders a critical, explorative approach and encapsulates a self-directed, active process of learning. It differs from the traditional teaching structure by utilizing key real-life problems which are used both as the initial trigger for learning and to create a point at which new learning or critical thinking can be applied and re-applied until an understanding is achieved. In this way information is built up over time and understanding is gained in small chunks that eventually form a larger whole (Clouston, 2005:13). PBL is also defined as an inquiry process that resolves questions, curiosities, doubts, and uncertainties about complex phenomena in life (Barell, 2007:6). This is the definition that this study will work with.

**Cluster 2**: There are five districts in the Free State province, namely, Motheo; Gariep; Lejweleputswa; Setsoto and Thabo-Mofutsanyana. Thabo-Mofutsanyana district is the biggest district in this province. It consists also of quite a number of schools. Most of the schools in the district are found in Qwaqwa. The schools have been grouped or clustered. Cluster 2 is one of the clusters (EMIS: 2010).

## 1.8 PROGRAMME OF THE STUDY

**Chapter 1**consists of an introduction, background to the study, motivation for the study, statement of the problem, definition of concepts and outline of the study. The introduction and the background give the necessary background and context and strive to put the problem more clearly. The purpose of the study and the relevance of the topic are indicated. The gaps are identified and indicated here. The relationship of the study to the discipline is explained. The research methods and aims of the study are briefly described in this chapter.

**Chapter 2** is about literature review regarding PBL.In this chapter the characteristics of problem-based learningare outlined. The reasons for teaching Technology through PBLare advanced. The importance of technology in the 21$^{st}$ century is explained broadly and a considerable amount of time is spent on why PBL is considered the best option for the teaching and learning of Technology. This is guided by the relevant theoretical framework and PBL models. Here the researcher indicates her views and understanding as well as the context in which she wishes to tackle this problem.

**Chapter3** describes the scientific research design employed in the collection and analysis of data. The qualitative research methodologies and the reasons for their choice are explained backing them up with authoritative sources on research methodology. The sampling and data analysistechniques are explained and their choicemotivated. The way the pilot study was administered is deliberated fully here. The purpose for the pilot study is explained fully and what it reveals is highlighted. Trustworthiness of instruments is accounted for.

**Chapter 4** is based on the analysis and interpretation of theresults. The findings of the results are thus presented.

**Chapter 5** presents the conclusions of the study and provides recommendations regarding the value of PBL fortheteaching and learning of Technology.

# CHAPTER TWO

# THE NATURE OF PROBLEM-BASED TEACHING AND LEARNING IN TECHNOLOGY EDUCATION

## 2.1 INTRODUCTION

This study, as it has been indicated in Chapter 1, is aimed at inquiring into the role that PBL can play in the teaching of Technology Education. Problem-Based Learning (PBL) is a learner centred pedagogy in which learners learn about a subject in the context of complex, multifaceted, and realistic problems (Hatting & Killen, 2003:39). As a learner-centred pedagogy, PBL is a facilitation strategy that has the potential to put learners at the centre of an activity and to make them accountable for their own learning (van Loggemberg-Katting, 2003:52).

This chapter is therefore engaged in the analysis of literature on the concept of PBL. The need for PBL in the teaching of Technology is thoroughly explored. The terms Technology and Technology Education are explained in the context of Outcomes-Based Education (OBE). The meaning of PBL and its evidence in OBE is unpacked. The roles that EXPOS and Technology Olympiads may play in the promotion of PBL are advanced. Finally, the pedagogy and assessment of Technology Education are looked at.

The next section unpacks some of the conceptual dimensions of PBL that validate the relevance of PBL for teaching Technology.

## 2.2 WHAT IS PBL APPROACH?

In the studies that they conducted, Muijs and Reynolds (2005:62) and Gravett (2005:19) indicate that within education, constructivist ideas are translated as meaning that all learners actually construct knowledge for themselves, rather than knowledge coming from the teacher and being ‘absorbed’ by learners. The basic point of departure of constructivism is that learning is an active process of constructing meaning.

In their study, Schmidt and Moust (2000:20-24) reviewed a number of studies that were aimed at uncovering the factors that affect small-group tutorial learning in problem-based curricula. Throughout the chapter they assume that PBL is a form of constructivist learning. Their findings were as follows:

- All learning in a problem-based curriculum starts with a problem. Problems are the starting point of learners’ learning process. That is the prominent role of the problem.
- The attempts made by the learners to make sense of the phenomena or event described in the problem can be considered a process of theory building (while discussing the problem, learners engage in formulating a theory).
- Learners construct their theory based on prior knowledge, on common sense, and on logical thinking.
- Because different learners tend to know somewhat different things or to think somewhat differently, theory construction becomes a collaborative effect that may lead to new insights that were not present in the individual participants before the analysis of the problem began.
- The collaborative effort, by which learners help each other on clarifying issues, is a central element of problem-based groups.
- PBL, conceptualized in this way, is a collaborative form of learning in which active construction of coherent mental models of knowledge, rather than simple processing of subject matter, is the focus of the activities.

PBL is also a form of contextual learning, because principles, ideas, and mechanisms are not studied in the abstract but in the context of a concrete situation that can be recognized as relevant and interesting, at best a situation that resembles future professional situations in which the knowledge acquired must be applied.

Harris, Marcus, McLaren and Fey (2001:311) point out that good tasks:

- present problems or puzzles that interest learners;
- help teachers get a reading of learner prior knowledge;
- provide an appropriate level of challenge and support for learners;
- encourage learners to collaborate in resolving difficulties;
- lead learners to discovery of important concepts and problem solving techniques
- Thatteachers using problematic tasks to drive classroom instruction must recognize the value of different solution strategies and explanations, and they must impart this belief to their learners.

Hallinger and Bridges (2007:25) contribute to the topic under discussion (PBL) as follows: "*Messy, real-life problems provide the starting point for learning in a radically transformed instructional environment that we refer to as Problem-based learning or PBL*". The learners jointly decide how to deal with these problems. In a PBL context, the teacher selects and sequence problems to ensure the activation of prior knowledge. The context in which information is learned should resemble, to the greatest extent practical, the types of contexts in which it will later be applied (Hallinger & Bridges, 2007:28). This is in agreement with Department of Education (2003:20) that solutions to real life challenges demand an interdisciplinary approach and this is what technology offers to learners.

Through its open-ended, problem-solving approach Technology links knowing with doing and so affords learners opportunities to develop the ability to apply and integrate their knowledge and skills from other learning areas in real and practical situations. In this way they become users and doers of technology, an ability that can be applied and developed further in various situations throughout their lives. Hallinger and Bridges (2007:28) point out that the advantage of this approach is that learners become more and more aware of how they can put the knowledge that they are acquiring to use. Adopting a problem-solving mentality, even when it is marginally appropriate, reinforces the notion that the knowledge is useful for achieving particular goals.

PBL results from the process of working towards the understanding of and/or resolution of a problem. Retention of information is improved while working within a problematic situation. PBL provides an opportunity, over time, to reflect on the story of how we come to understand some ideas and concepts. When we engage in a variety of learning experiences with this kind of 'let's figure it out' focus, we are acting out our own stories of how we grow from ignorance to knowledge, from misunderstanding to clarity of perception (Barrows & Tamblyn, 1980:18; Barell, 1995:120-124).

Evensen and Hmelo (2000: ix) claim that PBL has been mostly associated with medical education since the late 1960s. They indicate though that moving into the 21st century many of the advantages of a problem-based approach have become the generally articulated outcomes of education. They point out that these goals are not restricted to adult or post-secondary learning populations, that there is evidence of learners' problem-solving, researching new areas of interest and reflecting on their learning processes in high school, in middle school and even down through the elementary years. Evensen and Hmelo (2000:1) point out further that the workplace of the 21st century requires professionals who not only have an extensive store of knowledge, but who also know how to keep the knowledge up to date, apply it to solve problems, and function as part of a team. Schooling, in particular, must extend beyond the traditional preparatory goal of establishing a knowledge base.

The next sub-sections discuss PBL as a model of teaching and learning, the value of learning activities in a PBL curriculum, and evidence of PBL in OBE.

### 2.2.1 PBL as a teaching model

The assumptions underlying traditional preparation in educational programmes contrast sharply with those in PBL. Traditional preparation programmes view teaching as transmission of knowledge and learning as acquisition of that knowledge (Bridges & Hallinger, 1996:147). These authors argue that programme designers make the following assumptions about this knowledge:

- The knowledge is relevant to the learners' future professional role.
- Learners will be able to recognize when it is appropriate to use their newly acquired knowledge.
- Application of this knowledge is relatively simple and straightforward.
- The content in which knowledge is learned has no bearing on subsequent recall or use.

Programme designers that subscribe to this traditional notion assume that knowledge is learned most effectively when it is organized around the disciplines and taught through lecture and discussion (Bridges & Hallinger, 1996:147). But PBL rests on an entirely different set of assumptions (Bridges & Hallinger, 1996:147). PBL proponents assume that learning involves both knowing and doing. Knowledge and the ability to use that knowledge are of equal importance. Programme designers of PBL, according to Bridges and Hallinger (1996:147) assume that learners bring previously learned knowledge to each learning experience. Moreover, PBL adherents assume that learners are more likely to learn new knowledge when the following conditions are met:

- Their prior knowledge is activated and they are encouraged to incorporate new knowledge into their preexisting knowledge.
- They are given numerous opportunities to use it. The researcher feels that numerous opportunities in this instance could be EXPOS and Technology Olympiads.
- They encode the new knowledge in a context that resembles the context in which it subsequently will be used.

Bridges and Hallinger (1996:147) continue to state that PBL teachers further assume that the problems that learners are likely to encounter in their future professional practice provide a meaningful learning context for acquiring and using new knowledge. These problems supply cues that facilitate future retrieval and use of knowledge acquired during their formal education. Finally, PBL instructors assume that evaluation can play a major role in fostering the ability to apply knowledge if evaluation serves learning (formative) and is based on performance of tasks that correspond to the professional tasks that learners will face after completing their training.

Bridges and Hallinger (1996:149) further discuss the knowledge (content) in a PBL curriculum as follows. According to them, knowledge (content) in a PBL curriculum is organized around high-impact problems of professional practice. PBL adherents follow this maxim that is first the problem, then the content. Problems are used as stimulus for learning new content instead of the context for applying previously learned material. One major criterion guides the selection of content, that is, the content should be functional in fostering the understanding of the problem, possible causes for the problem, constraints that must be taken into account when considering (possible) solutions. In a PBL curriculum learners assume major responsibility for their own learning. The process by which they learn the content mirrors the realities of the workplace and the instructional goals (Bridges & Hallinger, 1996:150).

The above assumption about PBL clearly defines the technology education curriculum as it has been laid down in the policy documents reviewed by the researcher thus far. Unlike traditional educational programmes, the basic unit of classroom instruction is a project. Embedded in each project are a high-impact problem, a set of learning objectives, and a collection of reading materials that illuminate different facets of the problem. The problems are usually messy, ill defined, and a representative of the problems the learners will face after completing their schooling.

Barell (1995:120) also shares his views about the foundational elements within PBL. According to him, it should be evident that with problem-based learning we are trying to challenge learners to engage in significant, authentic, and meaningful intellectual work. This work places learners in the more active role of taking greater control of their own learning. Instead of their memorizing textbook explanations or rules and their applications, we challenge learners to think through tough, complex situations with friends and to arrive at conclusions. Barell (1995:120) stresses PBL as part of a larger unit because, he argues, if we want learners to understand significant concepts, principles, and ideas in depth and with clarity, we have to plan learning experiences that are focused on these concepts, that are coordinated, and that provide multiple opportunities for learners to think productively about them over long periods of time. The researcher feels that EXPOS and Technology Olympiads serve as those learning experiences.

Kelson and Distlehorst (2000:170-171) indicate that the pedagogical appeal of PBL is its perceived capacity to enable the following four learner outcomes:

- A flexible, useable knowledge base. This includes a repertoire of concepts and skills seen as essential for effective action in situations learners are likely to encounter in future practice.
- Skill at problem solving or reasoning. Here the authors stress that they are specifically referring to the hypothetico-deductive reasoning process where an encounter with the problem suggests hypotheses that guide further inquiry into the problem. Data from the inquiry process is used to strengthen or to weaken hypotheses until a reasoned resolution is reached. This process occurs with problems that seem to have a single solution as well as projects that may suggest a number of possible outcomes. Problem solving around ill-structured problems also carries with it the ambiguity factors: reasoning from uncertainty and decision making in the absence of complete knowledge.
- Skills in self-directed learning including recognizing the knowledge and skill demands of the problem; assessing one's own competence with respect to these; calling on a repertoire of strategies, sources, and skills to address the deficiencies; and developing new strategies, sources, and skills when those in the repertoire prove inadequate or require increased efficiency and effectiveness.
- Collaboration as a member of a team working toward three common goals: learning collaboratively, problem solving collaboratively, and achieving individual curricular outcomes collaboratively. The PBL group as collaborative learners is a group becoming knowledgeable; they are both constructing knowledge as contextualized by the problem and arriving at meaning common the scientific or other scholarly community.

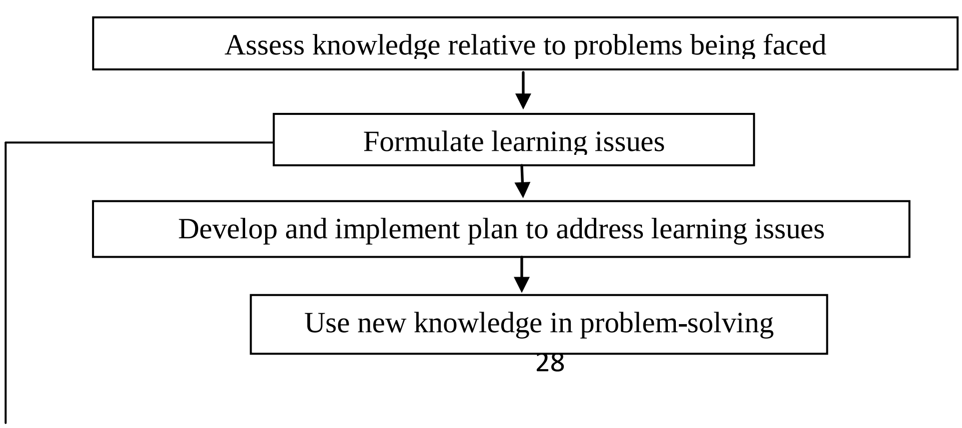
Kelson and Distlehorst (2000:171) label these four outcomes as knowledge, problem solving, self-directed learning, and collaboration.

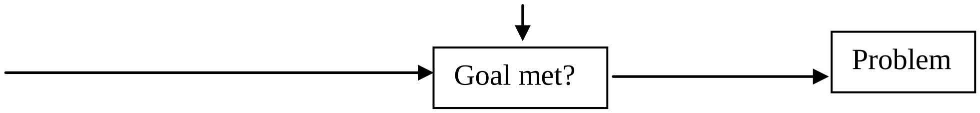
The PBL model can also be explained as perceived by Hmelo and Lin (2000:228-231). In this regard, the term PBL means different things at different institutions, leading to considerable confusion in the literature about what it is and how one should go about it. In order to understand the real value and potential that PBL may have to offer to learning and instruction, we need to clarify the particular PBL activities that are associated with self-directed learning (SDL) and the specific learning effects that result from engaging learners in these activities. Examining PBL and its effects on SDL in a detailed and specific manner enables us to take a closer look at the nature of these activities in relation to successful learning. There are thus several features of PBL that specifically support the development of SDL skills (Hmelo & Lin, 2000:228-231):

- The learner-centred nature of PBL;
- Having learners attempting to identify and solve a problem with their existing knowledge;
- Identifying knowledge deficits and generating appropriate learning issues;
- The independent research effort;
- Critiquing the resources used for research;
- Applying the new knowledge to the problem;
- Collaborative reflection on SDL.

Each of these features has an important function in supporting the development of SDL skills. Figure 2.1 below summarizes these SDL activities that occur during the problem solving itself.

**Figure 2.1: A self-directed learning (SDL) model (Hmelo and Lin 2000:229)**






The authors further indicate that the degree to which PBL is learner-centred is important in determining the opportunities for SDL. In traditional curricula, the teacher determines the type and sequence of information to be learned by learners. In the PBL curricula learning is learner-centred, meaning that the learners take much of the responsibility for their own learning. This is accomplished through careful design and sequencing of problems. The teacher performs the role of a coach by modeling and scaffolding the kinds of self-assessment questions that the learners need to ask themselves to be self-directed learners. For example, the teacher may ask questions such as “Why did you request that information?” or “What do you specifically hope to learn?” or “What more do you need to know?” Here the researcher is in complete agreement with the authors as during EXPOS or Technology Olympiad judges are urged to ask participants questions such as these. Hmelo and Lin (2000) add that the learners internalize these questions and pose them to themselves in a metacognitive fashion. They share seven aspects that PBL is able to achieve in learners in this regard. Firstly, it enables them to go further in self-assessing and understanding themselves on their lifelong journey of learning and knowledge building. Secondly, the learners are encouraged to attempt problem solving when they have a knowledge base that is inadequate to deal with the problems as posed, as indicated in figure 2.1. This helps learners to realize the inadequacies of their existing knowledge as well as to develop skills such as self-assessment. This experience sets the stage for learners to generate their own personally relevant learning needs and to plan for further learning. Through recognizing what they do not know, learners are able to create opportunities for learning and inquiry. This also serves to motivate the learners and to activate their prior knowledge, making it easier for them to understand new information.

Thirdly, as learners try to use their existing knowledge to solve a problem, they identify their knowledge deficiencies as learning issues. Generating learning issues gives the learners experience with setting their own learning goals relative to a problem faced. This enables learners to develop the skills and goal orientation that they need to be mindful self-directed learners.

Fourthly, and perhaps what is most obvious, is the factor related to the learners' independent research efforts. The learners in the PBL groups divide the learning issues and independently research their topic(s). Learners become proficient in locating appropriate information resources and in posing questions to experts when necessary. Because they have the opportunity to use this information-seeking skills and the knowledge gained on a variety of problems, they construct conceptual knowledge as well as procedures for solving problems. This prepares learners to become flexible and adaptive learners who can use their expertise in learning a range of novel situations.

Fifthly, as part of the independent research effort, learners need to critically evaluate the resources that they have used. They need to consider the reliability of the resources and how those resources contribute to knowledge construction. Sixthly, learners need to actually apply the fruits of their research to solving the problem. A key feature of the PBL methodology is that learners are learning in order to apply their knowledge. Learners learn to distinguish what is relevant from what is not and how knowledge can be used as a tool. According to Hmelo and Lin (2000:231), learners who learn in ways that facilitate an understanding of the relevance of information are more likely to develop contextualized knowledge structures that connect isolated pieces of information. Building such knowledge will facilitate access when relevant problems arise. Furthermore, contextualized knowledge is important in problem recognition and in monitoring problem solving.

Finally, learners frequently reflect on their SDL experience throughout the PBL process, not just at the completion of the problem solving. Reflective self-assessment is an important learning tool that scaffolds learners' inquiry in PBL settings. Learners reflect on the usefulness of the knowledge that they construct as a result of their SDL and on the processes in which they engage to achieve their learning goals. In addition, they consider how effective their strategies are and how they might improve in the future. Reflection is a critical component of the SDL process if learners are to transfer their strategies and knowledge to new situations. Reflecting on the PBL process will help learners identify what they need to understand, build connections between the procedures and concepts, and identify the causal mechanisms underlying a wide range of problems. Moreover, the collaborative discussions in the PBL group support reflection as learners share and compare their thinking with others in the group.

In the curricular overview the major elements of PBL as discussed by Barell (2007:27) are outlined as content, complex situations/problems worth investigating, objectives, teaching and learning strategies and assessment. Barell (2007:27) believes that these are foundational elements of curriculum on which PBL is based. According to him all curricula, whether problem-based or more traditional, involves these elements in one way or another. Barell (2007:27-33) outlines the elements of PBL as follows:

- *Content: Content is composed of those concepts, ideas, principles, skills, and dispositions. Content also refers to the ways of knowing and the methods of inquiry within each subject. We should learn the thinking processes associated with different subjects as well as learn key information, concepts, and principles. The most important processes to engage in are inquiry and subsequently conducting rigorous investigations guided by critical thinking.*
- *Complex situations/problems worth investigating: This complex, problematic situation is one that will arouse thinking because it involves doubt, difficulty and uncertainty. It may be an empirical situation such as figuring out how to redesign an elementary school playground, figuring out how to get elected president, or determining the extent of bacterial contamination in a school. Or the problematic situation may be a more abstract, future oriented experience such as trying to reason through the future of Microsoft or Google. This situation will start the inquiry, one that is complex and will grab learners' interest and attention. This is the 'problem' in PBL. This problem scenario should also contain elements of an authentic assessment of learners' understanding.*

- *Objectives: Objectives are what teachers strive to accomplish. This means asking the questions: "What do I want my learners to be able to do at unit/year end?" "What are my intended outcomes?" It is what learners do that counts toward learning, not what the teacher does. If the subject of the technology lesson is structures, teachers need to think of what they want learners to do with or about this concept. What will learners beengagedin intellectually? Teachers might ask them to read from text, or teachers might lecture or bring in demonstrations. But what are learners going to do? Teachers need to decide if they are going to analyze, compare, and create a model, draw conclusions, and so forth.*
- *Teaching and learning strategies (Long-term inquiry strategies): Long-term inquiry strategy is a set of learning experiences that, over time; engage learners in identifying questions worth pursuing, researching, analyzing and reporting the findings. Therefore, a strategy is a long-range plan, a series of logically connected episodes leading toward the resolution of some curiosity or issue.*

### 2.2.2 The value of learning activities in a PBL curriculum

To underscore the value of learning activities in a PBL curriculum, teachers may use extrinsic or intrinsic motivation strategies (Hallinger & Bridges, 2007:29). An extrinsic motivation strategy links task performance to consequences that learners value (Hallinger & Bridges, 2007:29). These may take one of several forms: rewards for good performance, instrumental value in achieving future success, and rewards achieved through competition with others (EXPOS and Technology Olympiads, among others, make use of this motivation strategy).

According to Hallinger and Bridges (2007:29), intrinsic motivation strategies are based on the assumption that learners will expend effort on tasks and activities that they find inherently enjoyable and interesting, even when there are few extrinsic incentives. This is the philosophy behind the PBL approach as advocated by the researcher in this genre. Each PBL project contains six elements that most learners find enjoyable or intrinsically rewarding. In terms of these elements, the PBL project (Hallinger & Bridges, 2007:29):

- Provides opportunities for active response: In each PBL project, learners learn by engaging in tasks similar to those performed in the future professional role-leading, discussing, recording, facilitating, making decisions, making oral presentations and the like.
- Includes higher-level objectives and divergent questions: At the heart of each PBL project are problem to be solved, a situation to be analyzed, knowledge to be applied, alternatives to be evaluated, decisions to be made, and consequences to be forecast. All these tasks involve high-order intellectual skills. The hallmark of PBL is the analysis, application and synthesis of knowledge, not simply recall.
- Includes simulations: In PBL environment teachers often incorporates simulations or role plays into the learning process.
- Provides immediate feedback: In a PBL environment teachers position themselves to observe learners and how they are using the knowledge they are attempting to master. When it becomes clear that the learners either do not understand a particular concept or are unable to use it appropriately, the teacher can supply immediate corrective feedback.
- Provides an opportunity to create workplace-like products: Most PBL projects conclude with a real-world product (for example, constructing a crane, constructing a model that utilizes renewable energy to improve the quality of life of your community). The expectation that they will transform their knowledge and solution into such products challenges learners, heightens their level of concern, and creates an incentive to excel.
- Provides an opportunity to interact with peers: Since the basic unit of instruction in PBL is a project, learners are required to interact extensively with their peers. Each learner has a role on the project team and participates actively in accomplishing its objectives.

Cross, Naughton and Walker (1986:254) provide the educational importance of project work – there are many educational reasons for the inclusion of projects in all school discipline, not least of which is their real-life multidisciplinary nature. A few of the educational reasons for the inclusion of projects in technology courses are highlighted below. Project work in technology develops:

- skills in the application and use of knowledge and expertise in solving particular problems;
- the ability to work with others;
- divergent and convergent thinking by giving due consideration to intuitive inspiration, guesses, and accidental developments as well as those achieved by means of a logical step-by-step progression;
- self-discipline and responsibility as the success or failure of the project is pupil-centered;
- creative abilities and encouraged enterprise and dedication; and
- Speculative thought and exercise ingenuity.

The main justification for project work is that it enables learners to develop their capabilities fully at their own pace. This provides them with a greater breadth of education than could be achieved by following the traditional narrow academic path, and so better equips them to solve the real problems which will have to be faced in their future professional lives (Cross et al., 1986:255). The researcher acknowledges and recognizes the reality of this statement in the way learners taking part in EXPOS and Technology Olympiads have been heard presenting their projects in district, regional, national and international levels.

### 2.2.3 Evidence of PBL in OBE

There is an overwhelming evidence of PBL in OBE. The principles of OBE are still evident even in CAPS. Careful scrutiny of C2005, RNCS, NCS and CAPS reveals that OBE remains the basis of curriculum transformation in South Africa. This is so because the transformation version of OBE as adopted in South Africa is hooked onto the national constitutional preamble. According to Spady and Schlebusch (1999:48), outcomes take many forms, ranging from the simple to the complex, from micro to macro, and from those tied to specific content to those influenced by the nature of complex contexts and settings. The authors use the picture of a mountain to define and illustrate some of these major differences. They point out that at the bottom of this mountain one finds the simplest, most micro, and most content-imbedded form of learning demonstrations. They call them discreet content skills. They are the most common form of school assignments – learning tasks of which elements and structures are usually quite well prescribed by the teacher.

In the middle sector of the mountain are complex and well defined kinds of performances that involve what are often called higher order competencies. These relate to complex problem-solving and those that require learners to create and shape their own performances. The latter are called unstructured task performances (Spady&Schlebusch, 1999:49). At the top sector of the mountain one will find the most complex, macro, and context-imbedded forms of learning demonstrations. They are called complex role performances. Spady and Schlebusch (1999:49) agree that these performances are actually the ultimate ‘proof of the learning pudding’. They indicate, though, that the most significant challenge posed by this mountain scenario – and by C2005, is that several of its critical outcomes compel learners and teachers to climb to the higher levels to address and achieve outcomes of significance that are defined as real-life role performance abilities, that is the things that they will be required to do as young adults in this rapidly changing world. This is a clear-cut evidence of PBL in the teaching and learning of TLA.

The PBL-based approach to teaching of technology is informed by PBL theory. The next section is dedicated to the discussion of this theory.

## 2.3 THEORETICAL PERSPECTIVES OF PBL

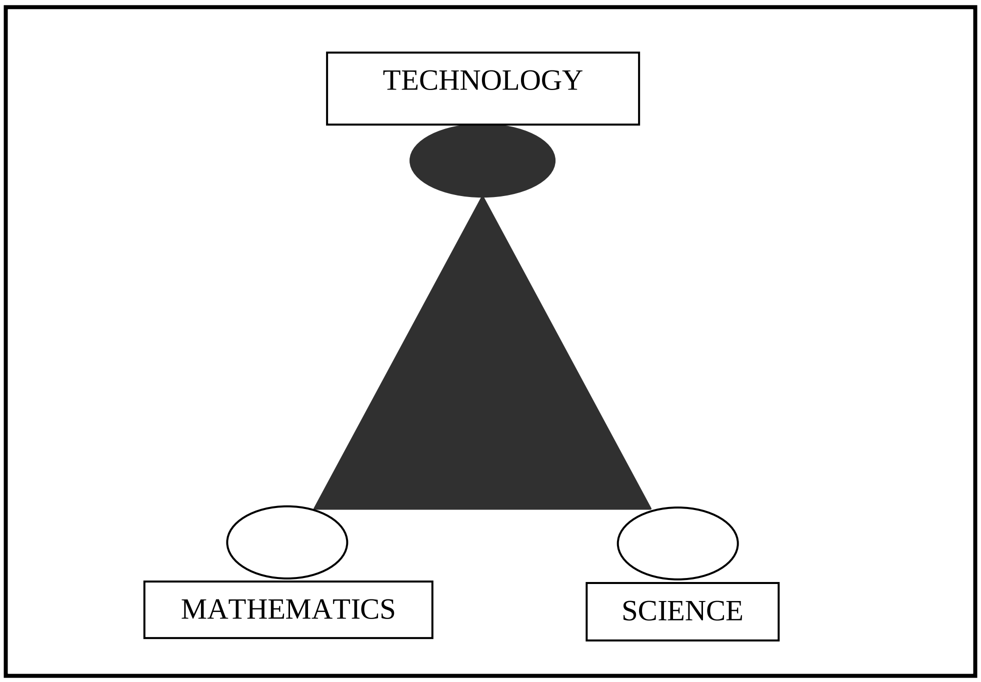
### 2.3.1 Technology and Technology Education

Pudi (2007:36) indicates that the definition of Technology is broad and can be defined in terms of what we need to achieve with that definition. He points out that different authors define Technology in different ways. According to Van Rensburg (2008:42), technology is to design and make, under safe conditions, products of high quality by the creative application of knowledge and skills within the framework of a problem-solving process. Naughton (in Cross & McCormick, 1997:2) indicates that equating technology with machinery is very common nowadays. He warns, though, that the equation of technology with machinery is clearly valid in the sense that it represents common usage, but it has severe limitations. Cross et al (1986:27) refer to technology as the ‘application of scientific and other organized knowledge to practical tasks by social systems involving people and machines. According to Department of Education (2002:4), technology is the use of knowledge, skills and resources to meet people’s needs and wants by developing practical solutions to problems while considering social and environmental factors. This definition matches verbatim with the one of Department of Basic Education (2010:6), and this is the definition that the researcher will associate with throughout this study.

Technology Education can be seen as a comprehensive experience-based educational programme that allows learners to investigate and experience the means by which people meet their needs and wants, solve problems and extend their capabilities. It is concerned with the knowledge and skills necessary to develop, produce and use products or services, and how to assess the impact of these activities on humanity and the environment (Pudi, 2007:37-38). According to McCormick (1997:142) Technology Education, in being concerned with both the practical and the intellectual, offers challenges to learning researchers. This author, when elaborating on technological knowledge, points out that one of the challenges that technology presents to learning theorists is that it is able to put learners in the kind of positions that they find themselves in the real world, i.e. where the demands of tasks may be to some extent unpredictable and the knowledge and skills needed are not necessarily set by some prior instruction on a topic, concept or process. The author further points out that technological activity is by its nature multi-dimensional, requiring understanding from a variety of points of view, and hence it draws on subjects such as science, mathematics, economics and social studies. He again points out that technological activity is found in all spheres of life and that there are in fact many technologies, examples of which include foods, textiles and civil engineering. He concludes that this makes defining a knowledge base, and the search for a unique common set of procedures or concepts, particularly difficult. This difficulty of definition, and the fact that Technology Education draws on other subjects, again sets challenges for learning theorists in terms of the unpredictability of the knowledge required in some learning tasks and how such knowledge is used.

Makgato (2003:59) believes that mathematics, science and technology have common component which is problem solving (see figure 2.2 in this regard). Pudi (2002:36) explains that the relationship between Technology Education, Science and Mathematics can also be visualized as a triangle with the three learning areas at the apex of each other. He explains further that the area of the triangle represents the commonality between the three learning areas but with differing proportions.

**Figure 2.2: The common area between mathematics, science and technology (Pudi, 2002:37)**




The researcher would like to see Technology Education as a subject with its own knowledge structure. In agreement with Makgato (2003:60), the researcher believes that though there are areas of Technology Education that overlap with Science and Mathematics, Technology Education should not be considered as part of these subjects. Technology Education has a body of knowledge and skills of its own (Makgato, 2003:60; Ankiewicz, 1995b:248). In addition, Ankiewicz (1995b:250) argues in defense of Technology Education, that it should be viewed as a subject with its own epistemology, philosophy, aims, identity, structure, methods of inquiry, curriculum, didactics and opportunities for the promotion of problem-solving and other high-order cognitive skills. Below is a table (Table 2.1) that indicates some of the characteristics of science and technology to prove their uniqueness.

**Table 2.1: The relationship between Technology and Science (ORT-STEP, 1995:8)**

| Emphasis in Science | Emphasis in Technology |
|---|---|
| 1) Exploring existing phenomena to reach new knowledge.<br>2) Curiosity as a driving factor.<br>3) Working with an ideal and simplified world.<br>4) Research.<br>5) General problem statements.<br>6) Reliance on assumptions.<br>7) Truth, accuracy, the ideal.<br>8) Abstract/theoretical<br>9) Looks for uniform knowledge, that applies everywhere in the same way, i.e. ideal. | -Designing new products that did not exist before.<br>-Need/want as a main driving factor.<br>-Working in the real complex world.<br>-Design for application.<br>-Specific problem solution.<br>-Reliance on facts.<br>-Solutions should be effective, efficient, within acceptable tolerance.<br>-Concrete/practical.<br>-Looks for solutions that are optimal for specific situations. |

The following section is based on the thinking sub-processes of technological process, including the knowledge base and unique common set of procedures or concepts in Technology Education.

### 2.3.2 Technological knowledge and processes

It was indicated in section 2.2 that the basic point of departure is that learning is an active process of constructing meaning. PBL is an example of a constructivist design. In the study that they conducted, Muijs and Reynolds (2005:62) indicate that within education, constructivist ideas are translated as meaning that all learners actually construct knowledge for themselves rather than knowledge coming from the teacher and being ‘absorbed’ by learners. This will lead to authentic learning and deeper understanding, compared to the surface memorization that often characterizes other teaching approaches (Muijs& Reynolds, 2005:63). Muijs and Reynolds

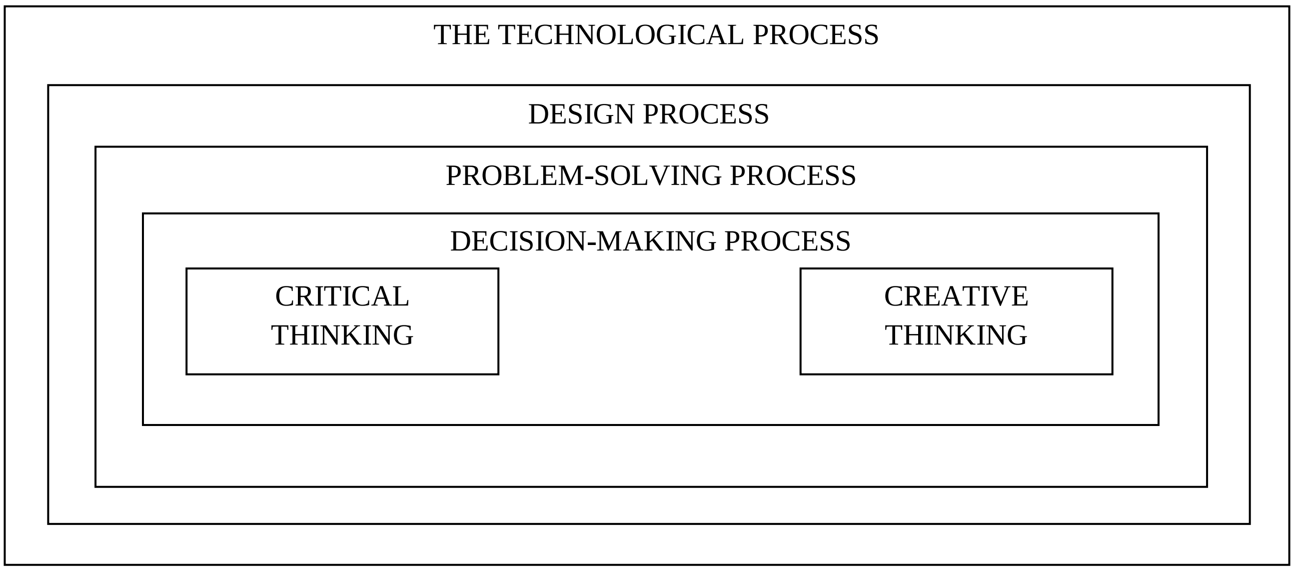
(2005:65) claim that exploration and problem-solving activities are key parts of the constructivist lesson that both allow learners to develop their thinking and meaning-making by developing novel combinations of ideas and thinking about hypothetical outcomes of imagined situations and events. These (Muijs& Reynolds) authors feel that in the constructivist classroom learners will often search for data or information that answers a question or helps to solve a problem.

According to ORT-STEP (1995:1) Technology is not just another subject taught at schools. It is a life style whereby learners are equipped with thinking, problem-solving and decision-making skills which enable them to address and cope with community needs. In his article McCormick (1997:142) supports with reasons that Technology Education is concerned with both the practical and the intellectual.

Ankiewicz (1995b: 250) contributes to the nature of the content of Technology Education as follows: “Technology Education in South Africa will consist of two intertwined components, namely a design component and an information technology component”. This author stresses that it is especially the design component which should revolve around the so-called ‘technological process’, namely identifying a problem/need, design, planning and constructing, and evaluation. This statement is closely related to the opinion of Department of Basic Education (2010:9) that states: “The design process (investigating, designing, making, evaluating and communicating) forms the backbone of the subject and should be used to structure the delivery of all the learning aims. Learners should be exposed to problems, needs or opportunities as a starting point. They should then engage in a systematic process that allows them to develop solutions that solve problems, rectify design issues and satisfy needs.”

PBL approach is about planning the proper implementation for Technology Education (Ankiewicz, 1995b:251-252). It is in the interest of the researcher to develop an approach that will assist teachers in the successful implementation of Technology Education, especially teachers in the most rural and disadvantaged communities of the eastern Free State Province (Qwaqwa is situated in the eastern Free State, in Thabo-Mofutsanyana District). McCormick (1997:250) and Ankiewicz (1995b:248) concur that Technology Education can make an important contribution to the general education at school level if it promotes the so-called technological process. Van Rensburg (2008:49b) indicates that the technological process requires the thinking process (critical and creative thinking), decision-making process, problem-solving process and design process. Figure 2.3 below shows the interrelatedness of these processes.

**Figure 2.3: Thinking sub-processes of the technological process (van Rensburg, 2008:49c)**




The central notion of outcomes-based education is to improve the thinking skills of learners. The critical outcomes of OBE stress that learners should be able to solve problems (Department of Education, 2002:1). The learner solves problems and completes tasks by using knowledge at his or her disposal, including prior knowledge. Pudi (2007:139) stresses that this mode of education has the advantage of giving the learner an opportunity to create new knowledge. This is in line with the notion of the technological process, a cycle of investigating problems, needs and wants and the designing, developing and evaluating of solutions in the form of products and systems (Department of Education, 1997b:86).

In the explanation of the thinking sub-processes of the technological process, Van Rensburg (2008:49b-49c) provides certain valuable aspects which lie at the heart of PBL. These are closely looked at subsequently.

### 2.3.2.1 Critical thinking

Critical thinking implies a process where information is sifted. It involves an intellectually disciplined process of active and skilled conceptualization, application, analysis, synthesis and evaluation of information that is collected by means of investigating, observation, experience, reflection, reasoning or communication and the use of the results to make progress in the field in which one works. This is in agreement with Pudi (2007:142) that critical thinking involves more than assessing isolated arguments in respect of clearly defined criteria using specifiable techniques. It is a unique kind of purposeful thinking in which the thinker systematically and habitually imposes criteria and intellectual standards upon his or her own thinking. The thinker takes charge of the construction of thinking by guiding the construction of his or her thinking according to the standards, and assessing the effectiveness of the thinking according to the purpose, the criteria and the standards.

### 2.3.2.2 Creative thinking

Creative thinking implies conceptualizing new and unique ideas. It requires hard work, application, commitment and perseverance to produce innovative, imaginative, divergent, impartial and possibly outrageous ideas to produce productive, copious solutions to problems. Pudi (2007:142) believes that the notion that there is a tension between critical and creative thinking is not true. The author further adds that critical and creative thinking are in fact inextricably linked and are joint aspects of effective thinking. This is in agreement with van Rensburg (2008:49b) that critical and creative thinking are separate processes, but they become linked in the thinking required for solving problems. That together they form aspects for effective thinking.

### 2.3.2.3 The decision-making process

Taking decisions is an important activity under all circumstances, and not only in technological situations. Learners should know when they need to take decisions, collect alternatives, evaluate alternatives and finally to select a suitable alternative.

### 2.3.2.4 The problem-solving process

The solution of problems (technological or other) depends to a greater extent on a combination of the critical and creative thinking processes, as well as the decision-making process. According to Ankiewicz (1995a:4) there is a stand to support introduction of higher-order cognitive skills, creative thinking skills, creative thinking and problem solving within the broad general education. This is expressed with equivalent terms by Pudi (2007:145) when he says problem solving cannot be confined to any subject or syllabi, but should be taught across the curriculum. This is in agreement with the theory behind this study.

To operationalise these skills, the teacher should employ transducers or means to convert them into observable behaviour (Pudi, 2007:152). When assessing for thinking skills teachers have to operationalise the thinking skills in question because they cannot be measured directly due to their conceptual nature (Pudi, 2007:152). The Technology Olympiads and EXPOS, as will be discussed in section 2.7, are the operationalisation processes of these thinking skills.

### 2.3.2.5 The design process

There is a close relationship between the design process and the problem-solving process. The design process is the application of the problem-solving process. The design process includes all the sub-processes mentioned above. The design process involves identifying needs and wants, generating ideas and choosing a final idea, realizing the solution and then evaluating, testing and improving the solution. McCormick (1997:141) depicts the process as follows:

- As a relief from tyranny of a content-laden and dominated curriculum.

- As being more relevant in a world where there is an ever-changing (content) knowledge base.
- As a process that is more relevant to a ‘science for all’ curriculum.
- As more representative of the nature of ‘real’ as opposed to school or textbook knowledge or science.

Learning Aim 1 (LA1) states: “*The Technology subject contributes towards learners’ technological literacy by giving them opportunities to develop and apply specific design skills to solve technological problems*” (Department of Basic Education, 2010:6). It is also highlighted in the same source (Department of Basic Education, 2010:9) that the design process (IDMEC) forms the backbone of the subject and should be used to structure the delivery of all the learning aims.

### 2.3.3 The relationship between learning aims in CAPS, learning outcomes and critical cross field

The following discussion about the learning aims (within CAPS) and the learning outcomes (LOs) of TLA and their relationship with the critical cross field outcomes (CO’s) of Curriculum 2005 will serve to confirm that problem-solving should be part of the teaching of Technology. LA1 as stated in Department of Basic Education (2010:6) indicates that learners’ technological literacy should give them the opportunities to develop and apply specific design skills to solve technological problems. LO1 is in agreement with LA1 and states that the learner will be able to apply technological processes and skills ethically and responsibly using appropriate information and communication technologies (Department of Education, 2002:28). LA1 and LO1 address the following critical cross field outcomes (DoE, 2002:1):

- Identify and solve problems and make decisions using critical and creative thinking.
- Work effectively with others as members of a team, group, organization, or community.
- Organise and manage themselves and their activities responsibly and effectively.
- Collect, analyse, organize and critically evaluate information;
- Communicate effectively using visual, symbolic and/or language skills in various modes.

The assessment standards (Ass) for LO1 are organized under five integrated technological skills (processes). They include investigating, designing, making, evaluating and communicating. They very much resemble the stages of the design process, one can even claim that they are the design process-driven Ass. All theAss, along with those for LO2 and LO3, can be achieved through project-based learning experiences that expose learners to all aspects of TLA in an integrated way (Department of Education, 2003:21). In the first paragraph of Chapter 1 it has been explained that when one is doing either a project or a research project the teaching is problem-based. LO2 is the outcome that includes the Ass for technological knowledge and understanding. The learner is able to understand and apply relevant technological knowledge ethically and responsibly. The Ass in this outcome are organized under three content areas, being structures, processing and systems and control. Learners should be able to demonstrate achievement of these Ass in the process of completing practical project work (Department of Education, 2003: 22). LO 3 lists the Ass for Technology in society. The learner will be able to demonstrate an understanding of the inter-relationships between science, technology, society and the environment. The Assinclude indigenous technology and culture, impact of technology and bias in technology. Learners should be able to demonstrate achievement of these Ass in the contexts directly related to practical project work and in particular through investigating and evaluating particular aspects of the project work found in LO1. LO2 and LO3 address critical cross field outcomes 6 and 7 (DoE, 2002:1) stated as:

- Use science and technology effectively and critically showing responsibility towards the environment and health of others.
- Demonstrate an understanding of the world as a set of related systems by recognizing that problem-solving contexts do not exist in isolation.

In the following section the researcher wishes to indicate the importance of PBL in the teaching and learning of Technology.

## 2.4 A CASE FOR PBL IN THE TEACHING OF TECHNOLOGY

Here the researcher wishes to indicate the importance of PBL in the teaching and learning of Technology. In a study of the importance of PBL, Barell (2007:2) states that life does not come problem-free as it is full of challenging opportunities to learn, grow, reflect and enjoy. Barell (2007:2) then explains that PBL engages learners in life as we know it, that it is full of fascinating problematic situations worth thinking about, investigating and resolving. He then concludes that this may be the most obvious reason why PBL is important to consider. The researcher cannot help but feel that the underlying area of learning explained in this paragraph resembles TLA – an area of learning full of fascinating problematic situations worth thinking about, investigating and resolving.

It is argued that problem-based learning is not just a different method or style of teaching. Instead it is a different philosophical approach to the whole notion of teaching and learning (Savin-Baden, 2000:13). This author (Savin-Baden, 2000:13) adds that at the heart of this approach is the development of important abilities, such as flexibility, adaptability, problem-solving and critique. The researcher maintains that the abilities indicated relate well with TLA, in fact, they are core in the learning and teaching of the technology subject. Abilities such as these have been highlighted by government and industry as central to the development of future professionals (Savin-Baden, 2000:13).

According to Savin-Baden (2000:123), problem-based learning would also seem to be a form of learning which can take account of, and challenge, the idea that there is a body of knowledge to be gained, a series of meanings to be understood and a number of techniques to be acquired. In practice, PBL will largely be based within a particular discipline area, such as economics or engineering, and the problem scenarios will be based on key concepts about which learners are expected to know (Savin-Bade, 2000:126).

The following section strives to expose the structure of RNCS and CAPS as well as their relation with the problem-solving character of Technology.

## 2.5 THE STRUCTURE OF RNCS/CAPS TECHNOLOGY AND ITS PROBLEM-SOLVING CHARACTER

Teaching and learning must be aimed at developing technological literacy so that learners are empowered to cope with the challenges of a technological society (Department of Education, 2003:26). Inherent in the development towards technological literacy is technological capacity. In the South African TLA curriculum as contained in the policy documents, developing problem-solving skills lies at the heart of capability. Given that developing capability is a process, learners should be given multiple opportunities to demonstrate competencies in the learning outcomes. In Technology Education, the focus should be on the development of transferable skills leading to an interactive process approach to solve problems in a range of contexts (Department of Education, 2003:26).According to the Department of Education (1997a:28), TLA's rationale is to develop:

- an ability to solve technological problems by investigating, designing, developing, evaluating as well as communicating effectively in their own and other languages by using different modes;
- a fundamental understanding of and ability to apply technological knowledge, skills and values, working as individuals and as group members in a range of technological contexts; and
- a critical understanding of the interrelationship between the technology, society, the economy and the environment.

The fundamental issue in the above-mentioned rationale is that technology education is about solving practical problems by designing, investigating, developing and evaluating products and systems. According to Pudi (2007:165), the teaching of Technology differs from the way other learning areas are taught. This is because it follows the design approach – investigation, design, make, evaluate and communicate. What makes it challenging to learners is that this design approach is not applied linearly as learners are required to engage a range of skills in embarking on the design tasks – creativity, critical thinking, group work, drawing, etc. Since Technology Education is about problem-solving, both the product and process are important in its teaching

(Pudi, 2007:147), especially the process. Pudi points out that technology education is taught in terms of activities, and learners are involved in designing and developing solutions to problems, needs and wants.

## 2.6 ASSESSMENT IN TECHNOLOGY EDUCATION

Girl and Lee (2005:104) advise that implementing PBL entails the need for proper assessment. They postulate that in almost every study investigating PBL and curricula, there is always a section presenting assessment modes. It is therefore appropriate to address this issue when deciding to implement PBL or incorporate it in curricula. This reflects our stance with respect to PBL as a strategy that aims to foster deep learning and critical thinking skills rather than the acquisition of knowledge for assignment (Wilkie& Burns, 2003:110).

According to Department of Education (1997b:13), assessment refers to any activity used to appraise learners' performance. Also, assessment is used to monitor and encourage progress towards achieving specific outcomes. Assessment measures individual learners' attainment of knowledge and skills in a subject (Department of Basic Education, 2010:38).

The sub-section that follows is dedicated to the purposes of assessment.

### 2.6.1 Purposes of assessment

The main purpose of assessing learners should be to enhance individual growth and development, to monitor the progress of learners and to facilitate their learning (Department of Education, 2007:24; 2002:54; 1997b:5). A review of the literature on assessment in OBE (Department of Education, 2002:54; 1997b:5) indicates that one can distinguish between the following kinds of assessment. All of them should be dealt with in the classroom to ensure that assessment is an ongoing process (Van den Berg, 2004:282):

- Baseline assessment is usually used at the beginning of a phase, grade or learning experience to establish what learners already know.

- Diagnostic assessment is used to find out about the nature and cause of barriers to learning experienced by specific learners.
- Formative assessment monitors and supports the process of learning and teaching. It is used to inform teachers and learners about their progress so as to improve teaching and learning.
- Summative assessment gives an overall picture of learners' progress at a given time, for example, at the end of a term, or on transfer to another school.
- Systemic assessment is an external way of monitoring the education system by comparing learners' performance to national indicators of learner achievement.
- Alternative assessment whose purpose is to minimize the impact of the learner's special needs upon assessment performance.

An overview of the different kinds of assessment indicates that assessment is integrated with teaching and learning, and gives teachers a wider range of evidence on which to judge if learners are making progress and becoming competent in what they are supposed to know and be able to do (Van den Berg, 2004:282). Assessment also provides learners with expanded opportunities to achieve the set outcomes.

### 2.6.2 Assessment as a tool to develop higher-order thinking skills

According to Van den Berg (2004:281), when assessment is done, it should meet the requirements of current assessment policies. The author further adds that because assessment is an integral part of the teaching and learning process, it should always stimulate growth. Learners should show growth in the use of higher-order thinking skills (Van den Berg, 2004:284). Department of Education (2002:55) gives the following characteristics for assessment: It takes place over a period of time and is ongoing. It supports the growth and development of learners. It provides feedback from learning and teaching. It allows for the integrated assessment. It uses strategies that cater for a variety of learner needs (language, physical, psychological, emotional and cultural). It allows for summative assessment.

The section that follows is based on formal and informal assessment.

### 2.6.3 Formal and informal assessment for the 21st century Technology Education

According to Department of Basic Education (2010:38), assessment should be both formal and informal. In both cases regular feedback should be provided to learners to enhance the learning experience. Department of Basic Education (2010:38) provides the following information concerning formal and informal assessment:

#### 2.6.3.1 Informal daily assessment

- The informal daily assessment tasks are planned teaching and learning activities that take place in the classroom or given as homework tasks. Learner progress should be monitored during learning activities. This informal daily monitoring of progress can be done through questions and answer, short activities/written work completed during the lesson, practical investigation activities and homework exercises such as doing design sketches, practicing communication skills, evaluating or comparing products, etc. Informal daily assessment should not be seen as separate from the learning activities taking place in the classroom.
- Enabling tasks in Technology are used to develop skills and knowledge that will be used during Mini-Practical Assessment Tasks (Mini-PATs) and written tests/examination that will be assessed formally.
- Learners or teachers can mark the informal assessment activities. Self-assessment and peer assessment actively involves learners in informal assessment. It gives learners additional exposure to the learning materials and allows them to learn from and reflect on their own performance.
- The results of the informal daily assessment activities are not formally recorded unless the teacher wishes to do so. In such instances, a simple checklist or rating scale may be used to record this assessment. However, teachers may use the learners' performance in

these assessment tasks to provide verbal or written feedback to learners, the school management team and parents. This is particularly important if barriers to learning or poor levels are encountered. The results of the informal daily assessment activities are not taken into account for promotion.

#### 2.6.3.2 Formal assessment

- The teacher must plan and submit the annual formal programme of assessment to the school management team (SMT) before the start of the school year (see table 2.2). This will be used to draw up a school assessment plan in each grade.
- Formal assessment provides teachers with a systemic way of evaluating how well learners are progressing in a grade and in a particular subject.
- Formal assessment for technology will consist of mini-PATs and written tests or examinations.
- All formal assessment for grades 7, 8 and 9 will be school based and set internally.
- The end-of-year promotion mark will comprise of 40% CASS and 60% end-of-year examination. Table 2.2 below is about formal assessment programme in Technology.

**Table 2.2-Formal assessment programme in Technology (Department of Basic Education, 2010:39)**

<table>
<tr><td rowspan="3"></td><td rowspan="7">INFORMAL DAILY ASSESSMENT</td><td colspan="3">FORMAL ASSESSMENT:TERM MARKS</td></tr>
<tr><td colspan="2">Practical tasks & theory test/examination</td><td>TOTAL</td></tr>
<tr><td>Mini-PATs</td><td>Term test/examination</td><td></td></tr>
<tr><td>Term 1</td><td>70%</td><td>30%</td><td>100%</td></tr>
<tr><td>Term 2</td><td>70%</td><td>30%</td><td>100%</td></tr>
<tr><td>Term 3</td><td>70%</td><td>30%</td><td>100%</td></tr>
<tr><td>Term 4</td><td>70%</td><td>No test</td><td>70 X 1,43=100%</td></tr>
</table>

<table>
<tr><td rowspan="3">Promotion mark</td><td colspan="2">CONTINUOUS ASSESSMENT (CASS)</td><td>Final Exam</td><td>Promotion</td></tr>
<tr><td colspan="2">Term 1+ Term 2 + Term 3 + Term 4</td><td>Term 4</td><td></td></tr>
<tr><td>10 + 10 + 10 + 10</td><td>40%</td><td>60%</td><td>100%</td></tr>
</table>

This format means that the practical aspect of the subject forms a significant part of the term mark. Mini-Practical Assessment Task, as the name suggests, is designed to give learners the opportunity to develop and demonstrate their levels of ability (i. e. capability) as they progress through the task's activities. These tasks are structured according to the design progress: Investigate-Design-Make-Evaluate-Communicate. This is not always a linear process. Formal assessment in a mini-PAT does not need to cover all aspects of the design process each term. Table 2.3 provides a guide for the Mini-PAT per term.

**Table 2.3: A guide for the Mini-PAT per term (Department of Basic Education, 2010:39)**

| | TERM 1 | TERM 2 | TERM 3 | TERM 4 |
|---|---|---|---|---|
| GRADE 7 | **Mini-PAT**<br>Design+ Make | **Mini-PAT**<br>Investigate+<br>Design+ Make | **Mini-PAT**<br>Investigate+Design+<br>Make+<br>Evaluate+Communicate | **Mini-PAT**<br>Design+Make |
| GRADE 8 | **Mini-PAT**<br>Communicate+<br>Design+Make | **Mini-PAT**<br>Investigate+<br>Design+ Make | **Mini-PAT**<br>Investigate+Design+<br>Make+<br>Evaluate+Communicate | **Mini-PAT**<br>Design+Make |
| GRADE 9 | **Mini-PAT**<br>Communicate+<br>Design+Make | **Mini-PAT**<br>Investigate+<br>Design+ Make | **Mini-PAT**<br>Investigate+Design+<br>Make+<br>Evaluate+Communicate | **Mini-PAT**<br>Design+Make |

In terms of table 2.3, the learner must present the full design process once as a mini-PAT in each grade. The most effective tool used to assess learner performance in a mini-PAT is the analytical rubric. Learners must complete the mini-PATs for formal assessment under teacher supervision. Teachers assess the mini-PATs formally.

## 2.7 THE TECHNOLOGY OLYMPIADS AND EXPOS

Concerning the role that EXPOS and Olympiads play in the promotion of PBL, the researcher will start by reviewing the 2010 Murray and Roberts (M&R) Olympiad challenge. The 2010 M&R Olympiad (online) specification stated that 2010 FIFA World Cup in South Africa would be the biggest cultural and sporting festival the country would ever experience. It further stated that the 2010 challenge would be designed with soccer in mind. Here the researcher realises the authencity of the challenge. The 2010 challenge was stated as: Design and build a self-powered ball shooter that can travel from the start area to the shooting area and shoot a tennis ball at the goals without human intervention. The researcher here identifies the problem-based character of the challenge. The starting point for problem-based learning is a problem statement, which is often called a trigger since it starts the PBL case and prompts the development of learning issues. The challenge further indicates that the power source of the ball shooter may be mechanical, gravity, pneumatic, hydraulic or any combination of these.

The judging criteria of the design include performance, originality, and cost-effectiveness, efficient use of available materials, simplicity, safety, style, accuracy, design, creativity and innovation. The researcher would like to point out that these criteria items relate to PBL. There is a lot of evidence of learners using their imagination and innovation during PBL. Weldeana (2008:12) stresses that the main purpose of problem-based teaching and learning (PBTL) is to make learning innovative, lifelong and retainable. Barrows and Tamblyn (1980:191) indicate that the problem is first encountered in the learning sequence. The sequence is the order in which things happen; it is the style.

It is important at this stage to clarify the Technology Olympiads and EXPOS as operational processes of technological thinking skills. In this regard, the mission statement for ESKOM Expo for young scientists has been stated as follows: “We develop young scientists who are able to identify a problem, analyse information, find solutions and communicate findings effectively" (ESKOM, 2010:2).

ESKOM Expo for young scientists (EXPO) is South Africa's primary and only existing science fair for school learners where they have the opportunity to exhibit their own techno-scientific investigations (ESKOM, 2010:5). It is further indicated that by participating in EXPO, learners will increase their awareness of the wonders of science, add to their knowledge and entrepreneurial possibilities, while broadening their scientific horizons. The M & R Technology Olympiad has been explained in the second paragraph of section 1.2 as a tool for exposing the high school learners to engineering disciplines and giving them the opportunity to enjoy technology as well as to apply their practical knowledge in finding solutions through technology for real life situations (Shan et al., 2006:95).

In EXPOS learners can enter their own individual projects, or a maximum of two learners can work together on a group project. According to ESKOM (2010:8) a scientific project is an investigation in which one tries to solve a problem or answer a question identified. One carries out an investigation by following a method that allows one to test an idea or solve a problem and come to a clear conclusion. The main ideas underlying both project work and problem-based learning are their emphasis on learning instead of teaching (Girl & Lee, 2005:123). Learning is an active process of investigation and creation based on the learners' interest, curiosity and experience and should result in expanded insights, knowledge and skills.

## 2.8 CONCLUSION

In this chapter the models of PBL were discussed. This involved analysing various sources and striving to indicate how PBL improves retention of information as well as its relevance for teaching and learning technology. The discussions also included the technological knowledge, technological processes as well as the relationship between Learning Aims (within CAPS), Learning Outcomes of TLA and the CO's of C2005. The M & R Technology Olympiads and EXPOS as operational processes of technological thinking skills were discussed intensively as well.

The reason for these detailed discussions was to showcase the suitability of PBL for the teaching and learning of technology. The structure of the NCS and CAPS for the Technology subject as a national policy was evidenced as problem-solving in character. Pedagogy and assessment in Technology Education was included in the discussions to prepare teachers for the successful implementation of CAPS.

The next chapter explains the plan that guided the empirical investigation, i.e. research design, methods and data collection techniques that were involved.

# CHAPTER 3

# RESEARCH DESIGN AND METHODS

## 3.1 INTRODUCTION

Chapter 1 has introduced and motivated the research problem, stated the research aim and objectives, as well as briefly explained the method of the study. Chapter 2 provided the theoretical background to the problem as explored in Chapter 1. By so doing, Chapter 2 addressed the first two sub-research questions (see Chapter 1 section 1.4) and achieved the first two research objectives (see Chapter 1 section 5). Chapter 3 focuses on the methods that were used to conduct the empirical investigation of the study in order to gather data to ascertain if problem-solving (PBL) approach in the teaching of Technology has an effect on learners' performance. Empirical research is the foundation of all scientific research and refers to an activity that systematically attempts to gather information through observations and procedures that can be repeated and verified (Neale &Liebert, 1980:7). Empirical research approach relies on observable evidence for its objectivity. In this empirical research the researcher wished to investigate the role that PBL plays in the teaching and learning of the Technology subject. Consequently, this chapter discusses the manner in which data were obtained and the methods that were used to obtain them, and the trustworthiness of the research instruments.

## 3.2 QUALITATIVE RESEARCH METHODOLOGY

This study is aimed at investigating the effectiveness of PBL in the teaching of Technology. The empirical study was conducted to have an understanding and insight of the impact of PBL towards the teaching and learning of Technology. The methodology for this study is purely qualitative in character. Most qualitative researchers concentrate on capturing an inside view and providing a detailed account of how those being studied understand events (Neuman, 2006:196). Neuman (2006:196) adds that qualitative researchers use a variety of techniques which include interviews, participation, photographs, document studies, etc. to record their observations consistently. For purposes of this study an inside view was captured because the participants were studied in their own setting. The techniques that were used in this study are also varied since they include interviews, observations of teaching and learning and document analysis.

A qualitative approach frequently utilizes observations and in-depth interviews; data are often in the form of words. Johnson and Christensen (2000:20) agree with Krathwohl (1993:13) that the study begins without structure but becomes more structured as it proceeds and it also operates in a normal setting. This statement is reason enough for the researcher to opt for this approach as it proves its consistency in striving for reality and objectivity. Qualitative researchers (most notably realists) can also be regarded as objectivists because they believe that the real world should be discovered by means of a systematic, interactive methodological approach and that knowledge arises from observation and interpretation (Fouche&Shurink, 2011:309). Contrastingly, qualitative research covers various methods that mainly concentrate on phenomena that happen in the natural surroundings. Also, the main accent of qualitative research is to obtain a clear picture of what is being studied (Leedy&Ormrod, 2005:133; Struwig& Stead, 2003:243).

Thus, in view of the above-mentioned statements and the perspective of the aim of the study (which is to investigate the nature of the impact of PBL in the teaching of senior phase Technology Education in Thabo Mofutsanyana District, Qwaqwa), use was made of the qualitative research methodology. In addition to the reasons outlined above, this choice was made because the researcher’s desire was for the study to be made up of firsthand knowledge of the research setting; to avoid distancing herself from the people and events she studied. The researcher also wished to be consistent in how she made observations. The researcher also considered a range of data sources and employed multiple measurement methods that are identified and explained later in this chapter, as is the case with qualitative researchers (Neuman, 2006:196).

### 3.2.1 Qualitative research design

The design that this study has opted for is ethnography. Creswell (2007:242) defines ethnography as the study of an intact cultural or social group (or an individual or individuals within that group) based primarily on observations over a prolonged period of time spent by the researcher in the field. For this study the researcher has been observing the activities of teachers and learners for a period of two years. This period is counted from the time when the researcher was a busy with the proposal of this study. The ethnographer listens to and records the voices of informants where the interaction happens with the intention of studying the cultural concepts and generating a cultural portrait. A good ethnographic study gives one an intimate feel for the way of life observed by the ethnographer (Fouche & Schurink, 2011:35; Rubin &Babbie, 2001:391).

The main features of ethnographic research as outlined by Flick (2006:227) include in the first instance the moments of the research process that cannot be planned and are situational, coincidental and individual, and then the researcher's skilful activity in each situation, eventually transforming into a strategy which includes as many options for collecting data as can be imagined and are justifiable. The data collection options that were used in this study are varied as explained in paragraph two of section 3.2 above. This study follows an ethnographic research design due to the researcher's intention to interview teachers and experts as outlined in table 3.1, to observe teaching and learning in two secondary schools that participate in M & R Technology Olympiad and two secondary schools that do not participate in the Technology Olympiad (M & R), to analyse documents (Technology teachers' lesson plans and workschedules; portfolios and files of Grade 9 Technology learners) in two secondary schools that participate and two secondary schools that do not participate in the M & R Technology Olympiad mentioned. This design was used to gain an understanding of the complexities of PBL in the teaching of Technology.

A discussion about the population and sample of this study follows.

## 3.3 POPULATION AND SAMPLE

### 3.3.1 Population

A population is the sum total of all cases that meet the definition of the unit of analysis (White, 2005:113). According to Bless, Higson-Smith and Kagee (2006:98), population is the entire set of objects or people which is the focus of the research and about which the researcher wants to determine some characteristics. The population can be described as all possible elements that can be included in the research. The population of this research consisted of all teachers who teach Technology insenior phase schools, heads of departments for Technology Education, experts in PBL as well as Grade 9 learners in Qwaqwa. It also consisted of Technology Education facilitators, organizers of M & R Technology Olympiads and judges of EXPOS and M & R Technology Olympiads in Thabo Mofutsanyana District.

### 3.3.2 Sampling

It is not feasible, if not entirely impossible to get hold of all the members of a particular population and to have them participate in the study. Sampling is part of our everyday life and all research involves sampling. One cannot study everyone everywhere doing everything (Huysamen, 2001:4; Mouton, 2001:103). Bless et al. (2006:98) define a sample as the subset of the whole population which is actually investigated by the researcher and whose characteristics will be generalized to the entire population. Cohen, Manion and Morrison (2002:92) state that there are four key factors in sampling, namely the sample size, the representativeness and parameters of the sample, access to the sample and the sample strategy to be used.

#### 3.3.2.1 Sample size

According to Neuman (2006:220), qualitative researchers rarely draw a representative sample from a huge number of cases to intensely study the sampled cases. For qualitative researchers, it is their relevance to the research topic rather than their representativeness which determines the way in which the people to be studied are selected. Also, the researcher is more concerned about whether the data collected from the sample is filled with useful information and broad in description, than the extent to which the sample's data can be generalized to the population (Struwig& Stead, 2003:125). A sample size depends on what one needs to know, the purpose of inquiry, what will be useful, what will have credibility and what can be done with available time and resources (Strydom&Delport, 2011:391).

The sample for this study is provided in table 3.1.The sample includes the following: two participating secondary schools in M & R Technology Olympiad and two non-participating secondary schools, two learners from each secondary school and one teacher from each secondary school as well as the experts as outlined.

**Table 3.1: Sample for the main investigation**

| **SAMPLE TYPE** | **NUMBER** |
|---|---|
| Learners participating in M & R Technology Olympiad. | 4 |
| Learners not participating in M & R Technology Olympiad. | 4 |
| Grade 9 teachers from secondary schools participating in M & R Technology Olympiad. | 2 |
| Grade 9 teachers from secondary schools not participating in M & R Technology Olympiad. | 2 |
| Learning facilitators for the Technology subject | 2 |
| Judges of M & R Technology Olympiads | 2 |
| **TOTAL** | **16** |

The methods that were used to gather data from the sample provided above are outlined in section 3.4 with the instruments that were used in this study.

#### 3.3.2.2 Non-probability sampling

In qualitative studies non-probability sampling methods are utilized. Non-probability sampling is often used in small-scale qualitative research and where it is not possible to state the probability of an element being included in the sample (Leedy&Ormrod, 2005:206; Strydom&Delport, 2011:391). This means that the researchersrarely determine the sample in advance and have limited knowledge about the larger group or population from which the sample is taken (Neuman, 2006:220). Non-probability sampling refers to the case where the probability of including each element of the population in a sample is not known. It is not possible to determine the likelihood of the inclusion of all representative elements of the population into the sample. Some elements might even have no chance of being included in the sample. The non-probability sampling technique that was used in this study is described subsequently.

#### 3.3.2.2.1 Purposive sampling

Purposive sampling may be very fitting for a particular research problem and the people or elements are chosen for a specific purpose. In purposive sampling a particular case is chosen because it illustrates some feature or process that is of interest for a particular study (Strydom&Delport, 2011:392). This type of sample is based entirely on the judgment of the researcher in that a sample is composed of elements that contain the most characteristics, representative or typical attributes of the population that serve the purpose of the study best (Grinnel&Unrau, 2008:153; Neuman, 2006:222). For the purposes of this study, the sample for the main study (Table 3.1) and the sample for the pilot study (Table 3.2) were selected with the specific purpose in mind. This purpose being that they illustrate the adherence and non-adherence to PBL. The sample, according to the researcher, contains the most characteristics representative of the population to serve the purpose of the study. Purposive selection of participants represents a key decision point in qualitative research. It is related to non-probability sampling in the sense that the qualitative rather than the quantitative element of the information is important.

In purposive sampling the researcher must first think critically about the parameters of the population and then choose the sample accordingly (Strydom&Delport, 2011:392). Creswell (2007:125) adds that this form of sampling is used in qualitative research and that participants and sites are selected that can purposively inform an understanding of the research problem of the study. Observing the learners that participate in M & R Technology Olympiad and their non-participating counterparts was the form of sampling that was used to inform an understanding of the following research problem: how do Technology learners who participate in M & R

Technology Olympiad in Thabo-Mofutsanyana District Qwaqwa compare with the non-participants in terms of engaging in problem-based learning activities. The problem in this study is whether PBL is applied in the teaching of Technology as it should be or not. The other problem that was discussed in Chapter 2 is whether teachers of Technology realise the problem-based character of Technology subject or not. The sample outlined in table 3.1 was chosen with those problems in mind.

Research instruments are tools that are used to gather data from the field. For this study the following research instruments were used.

## 3.4 RESEARCH METHODS AND DATA COLLECTION INSTRUMENTS

There are various research instruments and depending on the type of research study, some research instruments will result in the researcher obtaining more accurate and useful data. For this study, interviews, observations of teaching and learning and document analysis were judged to be the appropriate techniques to collect data because of the following reasons:

- The idea of PBL is not yet clear to many educationalists;
- Technology Education in general and Technology in particular, need to be approached with caution so as to have a better understanding of it;
- Curriculum changes and revisions have caused an unnecessary stress to the teachers of Technology; and
- This research study needs answers for the overall poor performance of learners in Technology.

### 3.4.1 Interviews

PBL , though an approach that has been associated with medical schools back in the 1960s, is not yet well understood and applied where it may yield best results. The Technology subject is about solving practical problems, and therefore it is based on problems and needs. In order to learn from those who have experience in the subject (Technology), an interview schedule was drawn to tap their views of the participants and to understand the scope and depth of Technology.

According to Greef (2011:342), interviewing is the prominent mode of data or information collection in qualitative research. A questionnaire written to guide interviews is called an interview schedule or guide (Greef, 2011:352). The following advantages, as prescribed by Greef (2011:352), of the interview schedule were regarded as important for this study:

- '*It provided the researcher with a set of predetermined questions that might be used as an appropriate instrument to engage the participant and designate the narrative terrain*' (see Appendix 3.2 in this regard).
- Producing a schedule beforehand forced the researcher to think explicitly about what she hoped the interview might cover.
- It forced the researcher to think of difficulties that might be encountered, for an example, in terms of question wording and sensitive areas'.

It was promised in Chapter 1 that the validity and reliability of the interview questions would be piloted on two key informants, three learning facilitators of the Technology subject and five teachers teaching Technology (see paragraph three of section 1.6.2). The researcher kept to her promise, but unfortunately, chaos resulted. The debriefers (mentioned above) were not ready to perform this task. The following were evident, about the above-mentioned debriefers:

- Views were contradicting;
- Confusion on how to conduct the given task and unnecessary disagreements surfaced;
- Inadequate knowledge of grammar and sentence construction became issues as well; and
- Little knowledge (in other cases no knowledge at all) of research skills were evident.

The supervisor for this study was not at all happy about the choice of questions and their overall construction. The researcher suffered diminished enthusiasm and energy and there was mixed feelings on whether to continue with the study or not. More delays were experienced and a feeling of uncertainty prevailed. With the continued support and advice of the supervisor, this became a learning curve when he made the researcher aware that he had to review her interview schedule before going to the field for the pilot or main data collection. It was a send back mission to review literature on the compilation of the interview schedule and guidance about matching the questions to the research questions.

The researcher, with the motivation of her supervisor decided to rephrase and to re-pilot the reviewed questions. In the real world and in research specifically, what suffice are reality and honesty and not anticipations, wishes and dreams. Also, according to Lincoln and Guba (1985:41), the naturalist allows the research design to emerge (flow, cascade, unfold) rather than to construct it preordinately because it is inconceivable that enough could be known ahead of time about the many multiple realities to devise the design adequately. This is so because what emerges as a function of the interaction between inquirer and phenomenon is largely unpredictable in advance, the inquirer cannot know sufficiently well the patterns of mutual shaping that are likely to exist, and the various value systems involved (including the inquirer's own) interact in unpredictable ways to influence the outcome.

As a result of the above incidence, the questions, before being administered to the judges of M & R Technology Olympiad and Technology teachers, they were verified by the deputy principal (curriculum), who is also an organizer of M & R Technology Olympiad (in Thabo Mofutsanyana District). He holds an honours degree with a research component in Technology Education. The instruments were also sent to the supervisor (who is well experienced in the field of research) for evaluation and comments.

Another data collection strategy that was utilized in this study, observation, is discussed fully in the following section.

### 3.4.2 Observation

Observation of teaching and learning was conducted in two secondary schools that participate in M & R Technology Olympiad and two non-participating schools. Although a seemingly straightforward technique, observation must be pursued in a systematic way, following scientific rules if usable and quantifiable data are to be obtained (Bless et al., 2006:114-115). The authors further add that one should keep the following rules in mind:

- '*Observations serve clearly formulated research purposes. Thus, observations must be planned systematically, specifying what and how to observe*'. I this regard, the researcher planned in advance what she needed to observe, also, how to observe it. What the researcher intended to observe was whether PBL was applied and how it was applied, also, how the application or non-application of PBL affected the learning and participation of learners.
- '*Observations should be recorded in a systematic, objective and standard way*'. The observations were recorded in a systematic way in the sense that the behaviours (attentive listening, problem solving, excitement, inquiry, excitement, inquisitiveness) of learners were recorded in the way in which they occurred (following one another). The researcher strived to be objective by observing the behaviours continuously. The behaviours were observed persistently as detailed in section 3.7.1.
- '*Observations should be subjected to control in order to maintain a high level of objectivity. Thus, many observers should be able to record the same phenomena or events in the same way, with the same results*'. In order to maintain a high level of objectivity the researcher did not rely on her judgment only. The opinions of other judges (in M & R Technology Olympiad and EXPOS) were taken into consideration. Also, the opinions of the Technology subject facilitators were asked and considered before the final decision was taken.

This data collection strategy was not easy to conduct at all. Some teachers were not very reluctant to be observed while in the process of teaching. Other teachers were reluctant they even went to the extent of indicating that they would first ask permission from their unions as, apparently, their unions were against the carrying out of observations in schools. The researcher acknowledged the ethical right of the participants to refuse to participate in the research. After all, this study is such that participation is voluntary. The researcher, in such cases, approached another school which served the purpose of the research (that is, participating or non-participating in M & R Technology Olympiad). As a result, there were some delays and a lot of time was lost.

Bless et al. (2006: 114) warn about the weakness of this method. They maintain that people who feel that they are observed may change their behaviour, become uneasy or stop activities altogether.

The third and fourth methods of data collection that were considered in this study are the study of documents and secondary analysis (Strydom&Delport, 2011:379). Therefore, the following section is dedicated to document analysis.

### 3.4.3 Document analysis

Qualitative researchers use a variety of techniques. They also consider a range of data sources and employ multiple measurement method (Neuman, 2006:196). As a result document analysis was also undertaken. The documents that were analysed were the lesson plans and workschedules of Technology teachers from two secondary schools that participate in M & R Technology Olympiad and two non-participating secondary schools. Also, portfolios, files and journals of Grade 9 learners were thoroughly studied. Past records of Grade 9 learners (files and portfolios) were also closely scrutinized. The documents were studied to find out if there was any application and/or non-application of PBL and whether the application and/or non-application had any contribution in the performance and achievement of Grade 9 Technology learners.

Babbie and Mouton (2001:303) present a perceptive version of the usefulness and value of personal documents that can briefly be summarized as follows:

- '*They serve as a touchstone for the evaluation of theories, hypotheses and assumptions*'. The assumption which the researcher strived to evaluate is that the application of PBL has an outstanding effect in the achievement of Grade 9 learners in Technology.

- '*They enable the researcher to probe into the phenomenological heart of a human phenomenon*'. The researcher in this regard probed and scrutinized the documents specified above to assess if PBL was really applied, and if so, how and how it affected learning.
- '*They complement objectivity with subjectivity in the research process*'. The researcher, as a proponent of PBL, wished to complement her objectivity with subjectivity in the research process by analysing documents in participating and non-participating secondary schools so that facts and reality as seen and experienced could support the theory and assumption that PBL is the best approach for the teaching and learning of Technology.
- '*They provide us with a holistic and total perspective of a person in the context of his or her total life*'. By analysing the documents, the researcher wished to get a holistic and total perspective in the sense that aspects such as creativity, motivation, deep understanding of Technology and application of the learned content in real life were looked at in detail.
- '*They add to the sensitizing of concepts, theory development and verification. Beginning with vague, yet genetic concepts, social scientists can derive personalisations from the subject's point of view, thus allowing the subject's meanings to be attached to a conceptual framework*'. The theory that the researcher was developing and verifying in this regard is whether PBL has a noticeable effect in the teaching and learning of Technology.

## 3.5 THE PILOT STUDY

According to Strydom and Delport (2011:394), in qualitative research a pilot study is usually informal, and a few respondents possessing the same characteristics as those of the main investigation can be involved in the study merely to ascertain certain trends. Janesick (in Denzin and Lincoln, 2000:386) states that researchers, before devoting themselves to the arduous and significant time commitments of qualitative studies, it is a good idea for them to do some background work, or what he has called 'stretching exercises' – in the past named pilot study. Janesick believes that stretching exercises allow prospective qualitative researchers to practice interview, observation, writing reflection, and artistic skills to refine their research instruments.

During this short period, pre-interviews with selected key participants and a period of observations and document review can be helpful to researchers in a number of ways. It will allow the researcher to focus on particular areas that may have been unclear previously. In addition, the researcher may use pre-interviews to test certain questions. This initial part of the process allows the researcher to begin to develop and solidify rapport with participants as well as to establish effective communication patterns. By including some time for reviewing records and documents, the researcher may uncover some insight into the shape of the study that previously was not apparent (Janesick, 2000:386-387).

For the sake of this pilot study, the interview questions were piloted. A feasibility study was undertaken and some measuring instruments (as specified in paragraph five of section 1.6.3) were reviewed. The measuring instrument that was piloted is the reviewing of lesson plans and workschedules of one teacher from a secondary school participating in the M & R Technology Olympiad and one teacher from the non-participating secondary school. The sample in table 3.2 (below) was used in the pilot study.

**Table3.2 -Sample for pilot study**

| **SAMPLE TYPE** | **NUMBER** |
|---|---|
| • Grade 9 teachers from secondary schools participating in M & R Technology Olympiad. | 1 |
| • Grade 9 teachers from secondary schools that do not participate in M & R Technology Olympiad. | 1 |
| • Organizer of M & R Technology Olympiad in Thabo-Mofutsanyana District | 1 |
| • Expert in research methodology | 1 |
| **TOTAL** | **4** |

Some observations surfaced from the pilot study. These are explained subsequently.

### 3.5.1 Interview questions

The interview questions were piloted to test and detect any flaws with respect to their content. The following were evident:

- Grammatical mistakes: the experts as identified in paragraph three of section 3.4.1 indicated that the grammar in some sentences was not correct.
- Ambiguity in some questions: the experts also suggested that some sentences were ambiguous and corrected them accordingly. Also, certain sentences were replaced with clearer ones.
- Negatively phrased questions or double negative: the experts were also concerned about certain questions. They indicated that those questions were negatively phrased. These questions were rephrased in a more acceptable way.
- Poor and confusing questions: the experts were also concerned with the layout of questions in the schedule. They indicated that the layout of the questions was confusing and could lead to non-response or other errors. They were also corrected as preferred by experts.

In the final drafts (see Appendices 3.2 and 3.3) that were drawn, problems associated with the understanding of the questions, ambiguities and grammatical mistakes were eliminated.

### 3.5.2 Undertaking a feasibility study

According to Sarantakos (2000:293), the researcher can ascertain facts about the neighbourhood where the investigation will be done by undertaking a feasibility study. The feasibility study serves to check about the accessibility of the respondents, the safety of the area and whether women could be accommodated as fieldworkers.

In this regard, the researcher undertook as comprehensive and accurate an assessment as possible of the situation at schools where the main investigation would be conducted. This exercise of the pilot study was rather scary. Many crimes are happening in and around schools of late and it was a shock to realise that one of the schools which was targeted for this investigation was a hive for criminals. This served as an eye-opener and the researcher could not associate herself with this institution anymore.

### 3.5.3 Testing of measuring instruments

The instrument that the researcher tested in this regard was the review and analysis of documents. The documents that the researcher analysed are the lesson plans and workschedules of Technology teachers. This exercise was performed with one teacher from a secondary school participating in M & R Technology Olympiad and one teacher from a non-participating secondary school. This element of the pilot study showed that the variables such as teaching experience, qualifications, age and gender of participants needed to be controlled as they had a considerable amount of influence in the results of the research. This aspect of the study receives attention in Chapter 5 when recommendations are made.

It was anticipated (in paragraph three of section 1.6.2) that the learners who participate in M & R Technology Olympiad would be compared with their counterparts by means of a miniPAT, but as the study unfolded it became evident that phenomenon was largely unpredictable in advance because the various value systems involved interact in unpredictable ways. The comparison was therefore not conducted because of factors beyond the researcher's control. These factors receive attention in Chapter 5.

### 3.5.4 Permission to conduct research

Permission was sought from the Department of education (Free State) to carry out the study (see Appendix 3.1). According to Mouton (1996:42), rules of research conduct regulate the behaviour of social scientists and ensure protection of the rights of participants in research projects. These rights include the right to privacy, informed consent and confidentiality. Therefore, the research ethics, as required by the Research Ethics Committee of the University of South Africa (UNISA) were followed accordingly (see Appendix 3.4).

## 3.6 DATA ANALYSIS

Qualitative analysis transforms data into findings. Data analysis is the process of bringing order, structure and meaning to the mass of collected data (Schurink, Fouche& De Vos, 2011:397; Struwig& Stead, 2003:169). Data analysis involves the process of making sense out of data collected by consolidating, reducing and interpreting what participants have said and what the researcher observed. It is primarily an inductive process of organising the data into categories and identifying patterns among the categories. Qualitative analysis is a systematic process of selecting, categorizing, comparing, synthesizing and interpreting to provide explanations of the single phenomenon of interest (White, 2005:168; Schwandt, 2007:7). Basically, the following process was followed in the data analysis (Schurink, Fouche& De Vos, 2011:410-414; Leedy&Ormrod, 2005:150):

- Reading the data several times in-depth so as to familiarize oneself with content;
- Identifying the main themes and organizing the data;
- Organizing the data into smaller units in the form of main concepts, sentences and individual words;
- Identifying general categories and the saturation point(s) as interviews continued; and
- Summarising data and integrating it into text for reporting.

In this study, the above process was applied as follows:

- The lesson plans of technology teachers and learners' portfolios were perused several times so as to familiarize the researcher with PBL approach, if any;
- The data in the interview schedule received a lot of attention in order to identify the main themes so as to be able to organize data. The researcher read the transcripts in their entirety several times to get immersed in the detail to get a sense of the interview as a whole before breaking it into parts.
- Then the data was reduced by generating categories and coding it. Codes were mainly in the form of abbreviations of key words.

- The process of identifying general categories and saturation point(s) of unstructured one-on-one interviews was achieved by in-depth probing during interviews.
- For the analysis of observations of teaching and learning the researcher relied on codes. This acted as a means of sorting the descriptive data collected.

The section that follows will be dedicated to the trustworthiness of research instruments.

## 3.7 TRUSTWORTHINESS OF THE RESEARCH INSTRUMENTS

Lincoln and Guba (1985:300) maintain that there are four strategies for evaluating qualitative findings and enhancing trustworthiness, namely credibility, transferability, dependability and confirmability. These strategies were taken into consideration as explained subsequently.

### 3.7.1 Credibility

This strategy is an assessment of the believability of the research findings from the point of view of the participants and the broader readership. Credibility is synonymous with internal validity. Internal validity is concerned with the question: "Do the observed changes in the dependent variable actually relate to changes in the independent variable?" (Bless et al., 2006:93). According to these authors, in order to achieve high internal validity, a research design should control as many extraneous variables as possible, and should deal with problems such as history, maturation, regression to the mean, test effects, instrumentation effects, experimental mortality and selection bias. The credibility strategy employed entails the criteria: prolonged engagement, persistent observation, triangulation, peer debriefing, negative case analysis, referential adequacy and member checking.

The researchers applied persistent observation as a strategy. The technique of persistent observation adds the dimension of salience to what might otherwise appear to be little more than a mindless immersion (Lincoln &Guba, 1985:304). The authors further add that the purpose of persistent observation is to identify those characteristics and elements in the situation that are most relevant to the problem or issue being pursued and focusing on them in detail. The persistent observation criterion, apart from the fact that participating and non-participating secondary schools were observed persistently, has been applied by the researcher throughout these years (2008, 2009, 2010, and 2011) when she was a judge in Technology Olympiads and EXPOS. This is in agreement with the views of Lincoln and Guba (1985:192) when they indicate that the term of observation must be sufficiently long so that the more salient factors can be identified, and then, systematically studied for a sufficient period that their influence can be assessed.

The second strategy that the researcher applied is member checking. In this study the member checking criterion was utilized in that the respondents verified if the transcriptions were true or false. They confirmed verbally that the transcripts were a true reflection of what they said during the interviews.

Thirdly, peer debriefing was also applied. The peer debriefing criterion, as have been detailed in section 3.5.1, was also used in that the interview questions, before being administered to the judges of M & R Technology Olympiads and Technology teachers, were verified by experts who were requested to determine if they were appropriate by giving their honest opinions regarding sentence construction, grammatical errors, relevancy, validity and general language usage.

### 3.7.2 Transferability

Transferability refers to the degree that findings can be generalized to other settings, contexts or populations. Transferability is synonymous with external validity. According to Bless et al. (2006:93) the researcher must consider two factors in order to achieve high external validity. First, the sample must be representative of the population in question. Second, the researcher must ensure that the study simulates reality as closely as possible. Techniques for ensuring less reactivity include making data collection as unobtrusive as possible and testing people within their usual surroundings. The transferability strategy is based on the criteria: nominated sample, comparison of sample to demographic data, time sampling and dense description.

The researcher used dense description. Lincoln and Guba (1985: 316) indicate that the establishment of transferability by the naturalist is very different from the establishment of external validity by the conventionalist. Thus, they further point out that the naturalist cannot specify the external validity of an inquiry; he or she can provide only the thick description necessary to enable someone interested in making a transfer to reach a conclusion about whether transfer can be contemplated as a possibility. It is, in summary, not the naturalist's task to provide an index of transferability; it is his or her responsibility to provide the data base that makes transferability judgments possible on the part of the potential appliers (Lincoln &Guba, 1985:316). In this study the dense description criterion was used in that in this chapter, a thorough explanation of the research methods was provided to enhance the trustworthiness.

According to Lincoln and Guba (1985:316), the naturalistic inquirer is also responsible for providing the widest possible range of information for inclusion in the thick description; for that reason (among others) he or she will wish to engage in purposeful sampling. In this study, purposeful sampling was utilized in order to improve the possibility of the transferability of findings. Purposeful sampling can be pursued in ways that will maximize the investigator's ability to devise grounded theory that takes adequate account of local conditions, local mutual shapings and local values for possible transferability.

### 3.7.3 Dependability

Dependability is synonymous to reliability, that is, the consistency of observing the same finding under similar circumstances. Its strategic criteria entails dependability audit, dense description of research methods, stepwise replication and inquiry audit. The researcher used dense description of the research methods. This criterion, as have been explained above, is when the researcher explains the research design, data analysis and interpretations in detail. This has been achieved through the detailed explanations of research methods provided in this chapter.

### 3.7.4 Confirmability

Confirmability refers to the extent that the research findings can be confirmed by others. Confirmability is synonymous with objectivity or neutrality, that is the extent to which a researcher is aware of accounts of bias. Confirmability anchors on the strategic criteria: confirmability audit, triangulation and reflexivity.

Lincoln and Guba (1985:41) indicate that the naturalist prefers to negotiate meanings and interpretations with the human sources from which the data have chiefly been drawn because it is their constructions of reality that the inquirer seeks to reconstruct; because inquiry outcomes depend upon the nature and quality of the interaction between the knower and the known, epitomized in negotiations about the meaning of data; because the specific working hypotheses that might apply in a given context are best verified and confirmed by the people who inhabit that context. In this study the respondents were provided with copies of their transcribed interviews to verify that the transcriptions are true and correct as to what they had said during their interviews. They indicated verbally that the transcriptions were a true reflection of their interviews.

Regarding triangulation, a researcher deploys 'different methods' such as interviews, questionnaires, observation, testing, census data, and documents to validate findings (Richardson, 2000: 934; Lincoln &Guba, 1985:306-307). In this study data collection techniques such as interviews, observations and document analysis were used to improve the confirmability of the research findings.

## 3.8 CONCLUSION

In this chapter an outline of the research methodology, which is qualitative, was given. This included discussions about the research design, population and sampling, the pilot study, data collection instruments, data preparation, data analysis and trustworthiness. Certain lessons were learned in the process regarding the procedures and design of the research instruments. The pilot study helped a lot as a corrective measure to ensure trustworthiness of the instruments.

# CHAPTER 4

# DATA ANALYSIS, INTERPRETATION AND FINDINGS

## 4.1 INTRODUCTION

In the previous chapter the research methods decided upon were explained. The research design, which is ethnographic, was also fully explained. The four experts of the M & R Olympiad were interviewed. For ethical reasons, they are identified as Participant Expert 1 through to Participant Expert 4, abbreviated as P-E1 through to P-E4. Four teachers were also interviewed. They were interviewed at their respective schools. Again, for ethical reasons, they are identified as Participant Teacher 1 through to Participant Teacher 4, abbreviated as P-T1 through to P-T4. The interviews lasted for a month. Observations and document analysis were also conducted over a period of one and a half month. The researcher observed whether the application or non-application of PBL influenced and affected the learning process or not. The observation of teaching and learning and document analysis was conducted in two schools that participated in M & R Technology Olympiad and in two non-participating schools. The documents that were analyzed are the lesson plans and workschedules of Grade 9 Technology teachers and the files and portfolios of Grade 9 Technology learners.

The next section presents the research themes and questions from which these themes originated.

## 4.2 RESEARCH THEMES AND QUESTIONS

It has been alluded to in section 3.6 that the main themes would be presented so as to be able to organize data. In order to examine and analyze whether PBL was applied in the teaching and learning of Technology the researcher assigned the questions with themes that are core in answering them. Table 4.1 presents the themes and questions from which they emanated. Codes have been assigned to questions so as to be sure which question is being addressed, for example, question 1 from the interview schedule is coded as 1-IS and question 1 from the oral interview is coded as 1-OI;2-IS stands for question 2 from the interview schedule and 2-OI stands for question 2 from the oral interviews, etc.

**Table 4.1: Themes and questions from which these themes originated**

| THEMES | QUESTIONS |
|---|---|
| 1. Explanation of (PBL) | 1-IS, 1-OI |
| 2. The relationship between PBL and Technology | 2-IS |
| 3. Reasons for using PBL to teach Technology | 2-OI |
| 4. PBL: A need in the teaching of Technology | 3-IS, 3-OI |
| 5. Thinking skills targeted | 4-OI |
| 6. The relationship between design process and PBL | 5-OI |
| 7. Useful methods and approaches | 6-OI |
| 8. Frequency in using other methods compared to PBL | 7-OI |
| 9. Comparing participating and non-participating teachers | 4-IS, 8-OI |
| 10. Comparing participating and non-participating learners | 5-IS, 9-OI |

In writing up the processes of data analysis it is essential to provide ample evidence of the logic of the analysis. In the following section the focus is on content analysis of both the interview schedule and the oral interview.

## 4.3 FINDINGS FROM INTERVIEWS

This interview schedule was drawn in order to tap rich information regarding PBL from experts and judges of Technology Olympiads and EXPOS. The experts are not identified by name as mentioned in section 4.1 above. They are referred to as Participant Expert 1(P-E1) through to Participant Expert 4(P-E4).Also, the views of teachers from participating and non-participating backgrounds are vital for providing a thick description of the concept under discussion (PBL).

It is vital for the researcher to indicate to the reader here that for question 9 (oral interview), only two teachers were interviewed. These are the teachers whose schools participated in the M & R

Olympiad project (see Appendix 3.3 in this regard). Also, in question 4 (oral interviews), only teachers were interviewed since the question focused on the thinking skills that these teachers targeted through the application of PBL. As a result, the experts are silent in theme 9.

### 4.3.1 Explanation of problem-based learning (PBL)

All these participants agreed that PBL is an approach which is based on problems.P-E1 believed that PBL is based on problems. P-E2 attached a framework to this explanation when he added that “PBL relates to learning based on problem solving”. P-E3’s input is remarkable as he adds: ’PBL is the manifestation of reality, solving of problems is a reality.’P-E4 summarized it more fully when he said: “PBL is actually an approach that assists learners to associate with the problem while learning”. The explanations of P-T3 and P-T4 bring an angle of content and context to the fore and this relates very well with the conceptual framework of the study on PBL. This is a theory (aimed at explaining and predicting phenomena) behind which this study is grounded. Schmidt and Moust (2000:24) state in this regard, that PBL is a form of contextual learning because principles, ideas and mechanisms are not studied in the abstract but in the context of a concrete situation that can be recognized as relevant and interesting; at best a situation that resembles future professional situations in which the knowledge acquired must be applied.

The main theme here, which is the explanation of PBL, has been addressed quite well by all the participants. They were aware that PBL is about using problems to learn. From the literature that was reviewed PBL was defined. In a PBL context, the teacher selects and sequence problems to ensure the activation of prior knowledge. The context in which information is learned should resemble to the greatest extent practical the types of contexts in which it will later be applied (Hallinger& Bridges, 2007:28). According to Barrows and Tamblyn (1980:18), PBL results from the process of working towards the understanding of and/or resolution of a problem. It can be gathered from these definitions, that all learning in a problem-based curriculum starts with a problem.

### 4.3.2 The relationship between PBL and Technology

The participants agreed that Technology is about solving practical problems. They also agreed that Technology is related to PBL. P-E3 stated it openly: “It is necessary for me to add that this approach is recommended for the teaching of Technology since Technology is about the solving of practical problems in life”.

At this point the researcher realises how the manifestations of this conceptual framework [in which the phenomenon (PBL) is classified in terms of the characteristics that it has in common with another phenomenon (Technology)] supports what Ankiewicz (1995a:251-252) means when he says that the PBL approach is about planning the proper implementation of Technology Education.

It is also interesting to note that the participants believed that PBL can assist learners to solve daily problems that they tackle in Technology and in everyday life. These reminds the researcherof Bridges and Hallinger (1996:147) when they indicate that PBL teachers assume that the problems that learners are likely to encounter in their future professional practice provide a meaningful learning context for acquiring and using new knowledge. These problems supply cues that facilitate future retrieval and use of knowledge acquired during their formal education.

### 4.3.3 Reasons for using PBL to teach Technology

It is evident from the answers of the participating teachers in the interviews that they used PBL in their teaching. It is also interesting to realise that some of the teachers are aware that PBL does not only mean one particular strategy, but a few. The question of P-T3 proves his total dependency on this methodological approach to teaching, when he asked: “How can you expect a teacher of Technology to tackle his teaching if not by that approach?” This question indicates that this teacher was aware and convinced that Technology should be taught through the PBL approach. The response of the fourth teacher is actually a ruling or a law as he indicated at length: “Problem-based learning is the strategy that should be used by all teachers throughout the curriculum. In Technology choosing problem-based learning is not one of the options, but, the only strategy to use since Technology is an area of learning with a unique character. Of course, I use it on a day-to-day basis to interest and motivate my learners. The retention of information learnt is also possible with this approach". The researcher is therefore in agreement with the teachers that PBL is not one more method to be used in the teaching of Technology, but the only option. The reasons that the researcher associates herself with have been emphasized by Hallinger and Bridges (2007:29) when they write that each PBL project contains six elements that most learners find enjoyable or intrinsically rewarding. In terms of these elements, the PBL project:

- '*Provides opportunities for active response: In each PBL project, learners learn by engaging in tasks similar to those performed in the future professional role-leading, discussing, recording, facilitating, making decisions, making oral presentations and the like.*
- *Includes higher-level objectives and divergent questions: At the heart of each PBL project are problem to be solved, a situation to be analyzed, knowledge to be applied, alternatives to be evaluated, decisions to be made, and consequences to be forecast. All these tasks involve high-order intellectual skills. The hallmark of PBL is the analysis, application and synthesis of knowledge, not simply recall.*
- *Includes simulations: In PBL environment teachers often incorporates simulations or role plays into the learning process.*
- *Provides immediate feedback: In a PBL environment teachers position themselves to observe learners and how they are using the knowledge they are attempting to master. When it becomes clear that the learners either do not understand a particular concept or are unable to use it appropriately, the teacher can supply immediate corrective feedback.*
- *Provides an opportunity to create workplace-like products: Most PBL projects conclude with a real-world product (for example, constructing a crane, constructing a model that utilizes renewable energy to improve the quality of life of your community). The expectation that they will transform their knowledge and solution into such products challenges learners, heightens their level of concern, and creates an incentive to excel.*

- *Provides an opportunity to interact with peers: Since the basic unit of instruction in PBL is a project, learners are required to interact extensively with their peers. Each learner has a role on the project team and participates actively in accomplishing its objectives*'.

### 4.3.4 PBL: A need in the teaching of Technology

The responses from the participants interviewed are worth quoting. P-E1 stated: “This will assist learners to solve problems in Technology”. P-E2 added: “It really is a need since this subject is concerned with problems”. P-E4 said: “The mere fact that Technology tackles problems shows and is proof enough that PBL is a need in the teaching of Technology”. P-T1 answered:” In Technology use is made of different methods and approaches”. P-T2 said: “Because the definition of Technology states: Technology is about solving practical problems”. The response from P-T3 was: “IDMEC in the Technology Learning Area is about following a certain procedure or steps in order to solve a practical problem”. By IDMEC this respondent means the cyclical steps of the problem-based design process which has been adopted in the teaching of Technology – investigate, design, make, evaluate and communicate. And P-T4 said: “Technology as a learning area in our curriculum since the invention of Curriculum 2005 is characterized of many unique features”.

The participants pointed out some interesting characteristics of Technology in their answers, which may be summarized as follows: solving of problems, concerned with problems, tackling of problems, certain procedures or steps and unique features. In section 4.3.1 the researcher mentioned that this study is grounded in the PBL theory. This theory is becoming clearer after these discussions. It is also interesting to note how the ideas of the participants relate with those elaborated by Bridges and Hallinger (1996:149) when they say that knowledge (content) in a PBL curriculum is organized around high-impact problems. Problems are used as stimulus for learning new content. The problems are usually messy, ill-defined and a representative of the problems the learners will face after completing their schooling.

### 4.3.5 Thinking skills targeted

In answering this question P-T1 said:“I can say I look for understanding, comprehension and application skills since in Technology learners solve practical problems”. P-T2 responded that the targeted skill is problem solving and the ability to relate what one has learnt to everyday problems. This supports what was initially indicated by the researcher when she pointed out that the study is grounded in theory that seeks to manifest in learners in surprising ways. The thinking skills that are targeted by P-T3 and P-T4 include, but are not limited to problem solving, creativity, innovation, investigative skills, following the scientific method, hypothesizing, predicting, vision forming, asking questions, formulating questions, reasoning, predicting, interpretation and application of knowledge.

The knowledge base of learners who are taught in a PBL way is rooted in knowledge creation, known by theorists as constructivism, because of the exposure that they enjoy during the building of the vocabulary and usage of process skills as observed by these participants thus far. The central notion of teaching Technology is to improve the thinking skills of learners. According to DoE (2002:1) learners must be able to solve problems and make decisions using critical and creative thinking.

The thinking skills that participants mentioned indicate that the use of PBL is important in instilling knowledge and deep understanding in learners. From P-T1 to P-T4 it is evident that not only understanding and comprehension of knowledge is targeted, but also the application of the content learned. This is one aspect of PBL that proves its usefulness in the teaching of Technology.

### 4.3.6 The relationship between design process and PBL

Let us consider the participants’ responses under this theme so that this relationship, if any, can be discussed in context. P-T1 presented his case as follows: “The design process makes use of skills such as investigate, design, make, evaluate and communication. These skills are applied when solving practical problems in Technology. That is how they relate”. According to P-T2, there is a close relationship between the design process and problem-based learning since this process, the design process, is used when problems are being solved. And according to P-T3:“I already explained that IDMEC, which is a procedure followed to solve a practical problem, is mainly used in order to make the solving of a problem easier and more understandable. At the same time, it makes learners develop and apply the thinking skills that I talked about earlier, while motivating the learners in the process of learning. Thus, the design process and problem based learning are closely related. I mean, while a learner is involved in the design processes”. The inputs of P-T4 are somehow closely related to those of P-T3: “The thinking skills that we talked about earlier, that involve problem solving, creativity and innovation, to mention but a few, are used during the design process. Earlier on I told you that the Technology Learning Area is a unique subject that consists of real life problems that can be solved by investigating, designing, making, evaluating and communicating. I want to stress it here, like I did before, that problem solving and problem based-learning are key to the Technology Learning Area, especially when the design process is tackled. The two processes, therefore, are closely related”.

It can be deduced that the participants agreed that there is a relationship between the design process and problem-based learning. They pointed out that the process skills and thinking skills such as investigate, design, make, evaluate and communicate, which are inherent in the design process, are actually a demonstration of problem solving, creativity and innovation used during the PBL activities. This is in agreement with van Rensburg (2008:49b) when she points out that the technological process requires the thinking process (critical and creative thinking), decision making process, problem solving process and design process. In addition, DoE (2002:1) adds that critical outcomes stress that learners should be able to solve problems.

### 4.3.7 The useful methods and approaches

The methods and approaches that participants claim to use surfaced from their responses. P-T1indicated that methods vary and that they include questioning, case study and discussion. P-T2 said that though question-and-answer method is traditional, it has not lost its value as it was still used a lot in the participant’s teaching. P-T3 used investigative activities; project work, mind mapping, brainstorming tasks and inquiry teaching. On the other hand, P-T4 was had grown to rely heavily on project-based learning and inquiry-based learning. This responded cautioned:

“Remember, the main focus here is to cater for skills such as problem solving and creativity. These skills force me to rely heavily on those approaches”.

The methods and approaches that the participants mentioned vary and in the researcher’s knowledge, are quite useful to be applied in the teaching of the content of Technology. It is once more of interest to note that the methods and approaches that P-T4 found useful is actually the PBL approach. These methods and approaches can be summarized in four terms: questioning, question-and-answer, project-based learning and inquiry-based learning. According to DoE (2003:26), in Technology Education the focus should be on the development of transferable skills leading to an interactive process approach to solve problems in a range of contexts.

### 4.3.8 Frequency in using other methods compared to PBL

According to P-T3, other methods and approaches are used within the problem-based approach. P-T4 supported this idea by pointing out that project-based approach, inquiry-based learning and problem-based learning are within each other. These statements were once uttered by Nieman and Monyai (2006:112) when they pointed out that when teaching is based on problem-based tasks a number of related teaching strategies, which include inquiry learning, problem solving and doing either a project or research project, can be considered. In conclusion, it is evident from the responses of these participants, that they made use of problem-based learning to teach Technology.

### 4.3.9 Comparing participating and non-participating teachers

The participants were very elaborative in their responses. As a result the researcher reports the findings by focusing only on the main ideas so that this theme can be addressed properly and specifically. P-E1 indicated that learners who participate in competitions are always alert and ready for challenges, while the same cannot be said with the non-participating learners. On the other hand, P-E2 stressed that learners who participate in M & R Technology Olympiads solve problems, design and construct models and provide solutions to problems. This participant further indicated that the approach that is used for the non-participating learners is outdated, and as a result their motivation and interest is very low. This participant also implied that the M & R Olympiads assist in improving the understanding of Technology when he said:“I would advise all schools to participate in competitions such as M & R Technology Olympiads for the sake of the better and improved understanding of Technology”.P-E3 indicated that learners who participate in M & R Technology Olympiads are motivated, curious to learn new things and ready to face challenges head-on. They also seem to apply PBL approach because all the time they tackle problems and strive to come with answers for difficult questions. On the contrary, according to P-T3, learners who do not participate in M & R Technology Olympiads do not show enough interest in their studies. They seem to be bored and perform poorly in their studies.

P-E4 also indicated that the learners who participate in M & R Technology Olympiad are more motivated than their non-participating counterparts. This participant also indicated that the participating learners apply what they learnt to everyday experiences. This participant then concluded by saying:“All technological skills such as problem solving and creativity they apply with ease. I so much wish that these competitions could be compulsory and be part of the curriculum”.

The researcher is in total agreement with P-T1 that these learners who participate in M & R Technology Olympiads are ready for challenges. However; this answer is not answering the question that has been asked. Also, P-T1 talks about teachers whose learners participate in M & R Technology Olympiads; no consideration is given to the non-participating teachers. The other respondents indicated the eagerness and enthusiasm of teachers whose learners participated in M & R Technology Olympiads. It is also of interest to notice that these participants were aware that the eagerness and enthusiasm of these teachers whose schools participated in M & R Technology Olympiads affected the performance of their learners in a positive way.

The following responses from teachers whose schools participate in M & R Technology Olympiads are categorized as falling under this theme because those benefits that are enjoyed by participating teachers are in essence a means for comparison. In simpler terms, they (teachers whose schools participate) benefited and those whose schools do not participate lacked those benefits.

The following responses by teachers whose schools participated were quoted verbatim so that the meanings and understanding behind their words cannot be distorted through reporting. P-T1: "*Participating in competitions like Murray and Roberts Technology Olympiads provides many benefits such as:*

- *Understanding the abilities and thinking skills of learners;*
- *Understanding the process of learning deeply;*
- *Treating concepts and theories in depth;*
- *Making learners who are more knowledgeable; and*
- *Increasing the interest and motivation of learners*'.

The second participant P-T2 indicated the benefits as follows:

- "*They help me as a teacher to realize the different potentials of learners, example, I have realized many times that we label learners as having barriers to learning, while in reality, we do not know how to approach content.*
- *When these learners are provided opportunities such as M & R Technology Olympiads, they are able to function and come out of cages that were created by teachers and become people that they really are.*
- *The context, which is competitions, creates an environment that allows them to function at a level which, we as teachers, never thought could be possible.*
- *Learners who were labeled as slow thinkers are able to perform extremely well. This is what I have experienced as a teacher whose school participates in M & R Technology Olympiads. The problem-based strategy or approach is an approach that benefits both the teacher and the learner*".

There is quite an agreement between the researcher and these teachers' responses. The researcher has experienced, during the period when she was involved in EXPOS and M & R Technology Olympiads, the same learning experience. It is very much true that when observing learners involved in these competitions, one cannot deny the fact that you as a teacher, understand the process of learning better. Also, it is true that there is this side of a learner that comes out so unexpectedly, even amazing. This intellectual aspect of the learner, because of this environment, is exposed and manifests itself strangely and miraculously. This is what the researcher has termed 'learning beyond borders', and it is without doubt a result of PBL.

The fact that concepts and theories are treated in great depth and scope is given in PBL. It is a characteristic of PBL approach. There is this culture in the classroom and Technology workshops – created by the formality of the teaching process – that as P-T2 explains, creates a cage or maybe makes learners to feel somehow restricted and inadequate. During competitions these learners are sort of freed from these uneasy feeling and bondages and they come out of themselves and are able to operate as intellectual beings. Their natural abilities are given room to blossom and there is no way they can be stopped. Their minds are able to reach maximum limits and it is almost frightening for teachers when they realize that they have been underestimating the potentials and abilities of their learners. These are the benefits, not only for learners, but also for teachers because as learners operate in those levels, their performance improves tremendously and learning and absorption of knowledge are spontaneous.

### 4.3.10 Comparing participating and non-participating learners

The responses of the experts in Technology Education indicate that learners who participated in the M & R Technology Olympiads are always alert, ready for challenges, solve problems, design and construct models, apply PBL approach, more motivated, curious to learn new things and strive to come out with answers to difficult questions. P-T4 presented had this to say:"The learners who participate in M & R Technology Olympiads seem to be more motivated than their non-participating counterparts. They go deep into content and are ready to face challenges. What I like most about them is the fact that they usually apply what they learnt to everyday experiences; authenticity, in simpler terms. All technological skills such as problem solving and creativity they apply with ease. I so much wish that these competitions could be compulsory part of the curriculum”.

On the contrary, the non-participating learners, according to these experts, do not apply PBL approach. They use an outdated approach to tackle problems, have low interest and low motivation, do not show enough interest in their studies, seem to be bored with the content laid in the Technology textbooks and are generally found to be performing poorly in their studies.

Teachers, as immediate implementers of the curriculum, are (from the point of view of the researcher) more knowledgeable about curriculum issues and can be trusted to give more honest and realistic comments and views concerning the activities and performance of learners in class. P-T1 stated in this regard: “I think learners from schools that participate in Olympiads benefit since some parts of content are drilled and revised, maybe even emphasized more”. P-T2 added: “The problem-based learning, I believe, would be best understood by those learners who participate in M & R Technology Olympiads as most of the time they solve problems on their own and are given challenging problems to solve. They therefore do benefit”.P-T3’sand P-T4’s responses concentrated on the following learners’ benefits:

- *‘Learners enjoy the exposure to challenging issues and are able to function at a higher level in as far as thought-provoking skills are concerned;*
- *They work independently and this should assist them to solve life’s challenges with ease;*
- *They are without any shadow of doubt, highly motivated;*
- *They treat concepts at sort of higher and deeper level; they stretch their minds and this mind-stretching-exercise is good for solving real-life problems during adulthood;*
- *The issue of stretching minds on the other hand is a good exercise for the faculty of education since real thinkers are not easily found these days;*
- *Learners become more motivated and interested in learning. They are no longer bored;*
- *Learners no longer function at the traditional level of knowledge acquisition, but create knowledge themselves;*
- *Learners who are able to discover theories and make inventions;*

- *The thinking ability of learners is freed and they function outside restrictions;*
- *The retention of information also improves extremely because they are responsible for knowledge creation;*
- *Most of the times these learners function and operate beyond the syllabi set for them;*
- *Application of knowledge learnt is spontaneous; and*
- *Learning is in short, beyond the borders of work schedules, syllabi and/or workschedules'.*

P-T3 further indicated that concepts are treated at a higher and deeper level. This fact is in agreement with the findings of the researcher that indicated that to develop competence in an area of learning learners need to have a 'deep' foundation of factual knowledge, understand these facts and ideas within a conceptual framework and organize knowledge in ways that facilitate retrieval and application of knowledge. P-T4 indicated that learners who participate in M & R Technology Olympiads create knowledge for themselves. This is in agreement with what the researcher pointed out in section 1.1 when she indicated that solving problems by themselves, instead of being told what the answer is or should be, helps learners to construct knowledge in a meaningful way. The point about discovering theories and making inventions, as pointed out by P-T4, is in relation with what Nieman and Monyai (2006:112) mean when they point out that problem solving engages both the teacher, as a learning mediator, and the learners, because new discoveries emerge from such participation. Also, according to these authors (i.e. Nieman &Monyai, 2006:112), new theories can be formulated because of assumptions that are confirmed or rejected by the solutions obtained. This agreement, between the Technology teachers (as curriculum implementers) and authors from the theoretical perspectives of this study (as proponents of PBL), has proven to the researcher that PBL is the best approach for teaching senior phase Technology Education in Thabo Mofutsanyana District, Qwaqwa.

In the following sections findings from the observations of teaching and learning and document analysis presented.

## 4.4 OBSERVATIONS AND DOCUMENT ANALYSIS

### 4.4.1 Observation of teaching and learning

The researcher intended to observe whether PBL was applied and how it was applied, and how the application or/and the non-application of PBL affected the learning and participation of learners. The behaviours that were observed, for the sake of this study are: attentive listening, problem solving, inquiry, excitement and inquisitiveness. These are explained subsequently.

#### 4.4.1.1 Attentive listening

Paying attention was very much relative to the activities that participating schools in M & R Technology Olympiads engaged in. These were the preparatory activities for the M & R Technology Olympiads. There was some degree of freedom and teachers seemed to be comfortable with it. Learners were working in groups of two. They were actually discussing, sharing ideas, pointing at their model, sometimes laughing. The process, as observed from where the researcher was watching, was also characterized by some form of 'trial-and-error' technique because learners would put something to their model, after some sort of discussion took it away and then replaced the item with an agreed item, checked its functionality, then seemed to be satisfied. The learners had unrestricted freedom of movement. In other instances they even left the Tech laboratory to go and look for whatever was needed, example: nails; wires; syringes or water. They seemed absorbed into these preparatory activities.

In the schools that did not participate in the M & R Technology Olympiads the opposite prevailed. Paying attention was very much teacher-directed. In one of these schools the learners were so silent that their teacher indicated to them that there was nothing to fear and that they should be free. It then came to the mind of the researcher that one of the distinctive features of the social sciences, as perceived by Mouton (1996:141), is that to a greater or lesser degree, the participants in social sciences, individuals or groups, are aware of the fact that they are 'objects' of investigation. Depending on the nature of the particular data source and the manner in which it is collected, human beings are aware of this situation when they participate in research and they tend to react to it. Thus, teachers seemed to approach their lessons differently than usual, only because of the presence of the researcher (though this cannot really be confirmed because the researcher did not have a background of them operating in a unobserved situation). In the other school it seemed like the lesson that was observed was drilled before. These learners were sort of reproducing content like it was done during the era of recitations and poems.

#### 4.4.1.2 Problem solving

Seemingly in schools that participated in M & R Technology Olympiads this skill was evident. The ‘trial-and-error’ technique that the researcher alluded to earlier on supports this statement. There were times when these learners engaged in deep thought-provoking activity, which was made even more obvious by the way they put their hands on their mouths to think or in other instances by their facial expressions and shaking of heads. The teacher’s role seemed like that one of a facilitator. The problem solving skill was more evident in the other participating school where, seemingly, the designed and made model-the learners were supposed to design and build a jet propelled model that will travel a distance of 3m and return-was not operating as it should Each one of the learners touched the wheels of the model, one positioned the syringe accordingly, the other one eventually placed the model upside down on the working bench to try and fix the problem. The expression on his face proved that he was in a deep thinking process. By the frown on his forehead one could tell that the process he was involved in was problem solving. Thus, the problem solving skill was more obvious and evident in both schools that were observed.

In the schools that did not participate in M & R Technology Olympiads the teacher did most of the talking. In the second non-participating school problem solving skill could not be observed easily as learners were writing a task. It was difficult, even impossible, to notice this behaviour or skill.

#### 4.4.1.3 Inquiry

The learners in schools that participated in M & R Technology Olympiads were involved in inquiry. Their foreheads told the story by the frowns which indicated deep thinking. During another instance, they rushed to the competition file, pointed at something and agreed, then returned to the model to add, removed or exchanged a certain part for the reason they apparently agreed upon. There was a time, during the observation process at the other participating school, when there was a noticeable disagreement among the group members. The teacher intervened and reported to the researcher that the argument was about the design. Apparently the dimensions of the design did not match those of the model from which it was made. The teacher did not supply learners with an answer, but advised them to look at the dimensions again and to take care of their conversions and scale used. This is an indication of inquiry, learners solving problems by themselves, instead of being told what the solution is or should be.

The learners whose schools did not participate in M & R Technology Olympiads were not provided the opportunities to inquire, to reflect or to ask questions. They were not given opportunities to analyze data or to reflect on their observations. Therefore the researcher is not sure how they would have reacted if such an opportunity was granted. An approach that was applied during teaching and learning did not resemble PBL. When applying PBL –as it was clarified earlier- learners strive to solve problems; they inquire; ask questions; debate issues and at other instances, are involved in deep thinking process. These learners (non-participating) were clearly absorbing information as it was related by their teacher. This approach is outdated and is used mainly by teachers who regard learners as empty vessels.

#### 4.4.1.4 Excitement

The learners in schools that participated in M & R Technology Olympiads showed observable excitement during observations. The excitement was a result of motivation and interest which the learners felt as they proceeded with their projects. The successes and discoveries that these learners made were the reason behind their excitement. It was pointed out earlier on that these learners, among many activities which they did, also shared some jokes and clapped hands after what seemed like an achievement or breakthrough. The uttering of the statement ‘I told you’ in the process by some of them also indicated to the researcher that these learners were excited about what they had achieved.

The learners in schools that did not participate in M & R Technology Olympiads were not excited at all during the observations of teaching and learning. They were reluctant to answer questions and it was evident that asking of questions is not a skill that they are comfortable with. If they were, which the researcher did not notice, they had a strange way of showing it. Their teachers emphasized attentive listening.

#### 4.4.1.5 Inquisitiveness

The learners in the participating schools did show a considerable amount of curiosity in learning. This desire to find out more about the topic they were researching was evident in their ways of seeking information. They accessed lots of websites. They also consulted books as well as Technology magazines. For example, a ‘popular magazine’-which is a Technology magazine-was cut and quoted from.

Learners from schools which did not participate in M & R Technology Olympiads showed some inquisitiveness to learn as well. They showed this by listening attentively to their teachers. The researcher might not really be sure if participating and/or non-participating learners were in fact inquisitive. What is presented here is only a result of the observation which was made. One can conclude that maybe observation is not a reliable instrument to measure human behaviours and traits.

### 4.4.2 Document analysis

The fact that human beings are ‘objects’ of inquiry in social research creates problems that are not encountered in the physical sciences (Mouton, 1996:141). Mouton (1996:141) further indicates that reactivity is a function of the kind of data source used and of the measures and control that the researcher uses. Mouton (1996:143) then points out that the products of human activities such as documents or texts cannot react to the fact that they are being researched. The researcher, as indicated in section 4.4, engaged in the analysis of the stated documents– lesson plans, files and portfolios of Grade 9 Technology learners, and workschedules of Technology teachers from participating and non-participating schools.

Some reactivity was reported during the observations which were made in section 4.4.1 above. Mouton (1996:157) advises that in order to compensate for limitations of some data sources used, one should employ different methods of data collection. It is hence an important principle to supplement the more reactive methods such as direct observation, with less reactive methods such as documentary sources (Mouton, 1996:157). Document analysis was conducted on the aspects reported in the sub-sections that follow.

#### 4.4.2.1 Lesson plans and workschedules

The lesson plan templates of teachers whose schools do not participate in M & R Technology Olympiads were different and very basic. The templates used had features that seek teachers to indicate basic and most obvious items such as learning area, grade, date, duration, learning outcomes, assessment standards, integration, learning activities and assessment. The Technology lesson plan templates of teachers in schools participating in M & R Technology Olympiads looked exactly the same. They produced a three page lesson plan template. In addition to the items mentioned it also had features that sought the teachers to indicate how the following items will be dealt with in a particular lesson: core knowledge and concept, integration, resources, process skills used, cooperative learning as a teaching strategy, models of cooperative learning, expanded opportunities (extension activities for high achievers) and remedial work for learners experiencing barriers to learning.

The lesson plans from participating schools were informative and the learning activities were explained in broad terms. Concepts were treated in a logical and deep way which required critical thinking from learners. Assessment was such that learners use and developed the process skills that include identifying phenomena, asking questions, refining questions, predicting, hypothesizing, identifying variables, designing, drawing graphs, measuring and observing. The teachers from non-participating schools prepared differently. Their preparation was in the form of a summary. Some sentences were not clear enough. The researcher was shocked to find out that such a big difference existed in schools of the same phase. The workschedules from participating and non-participating schools were exactly the same. They were provided by the learning facilitator so there was no difference at all.

#### 4.4.2.2 Portfolios and files of Grade 9 learners

Learners who did not participate in the M & R Technology Olympiads did not use a file, neither all the learners of schools that participated in the M & R Technology Olympiads. Only those learners who took part had files for the competition. Therefore, the researcher decided to analyze only portfolios so that differences and/or similarities could be identified easily. The portfolios were compared against the following criteria: amount of work, depth in content treated and assessment forms.

It was evident in the portfolios of learners participating in M & R Technology Olympiads that the amount of work was more than the one in schools that did not participate. Their books were nearly full but in non-participating schools they were approaching the middle of the book. The content from schools participating in M & R Technology Olympiads was treated thoroughly compared to the non-participating schools; this could be observed via the type of questions which were asked. In participating schools learners where asked to discuss concepts critically while in non-participating schools more emphasis was placed on matching exercises as well as fill in activities. Assessment forms were not at the level of Gr 9 learners in non-participating schools since-as it has been explained in the above sentence-the forms of assessment used did not encourage deep thinking from the side of the learners (matching exercises and fill in activities require learners to remember, thus analysis; interpretation and application of information were compromised). It is also a known fact that the manner in which content is taught informs how it will be assessed.

The following section brings this chapter to a closure.

## 4.5 CONCLUSION

In this chapter the data collected by means of an interview schedule and oral interview questions were analyzed. Four experts and four teachers from two schools participating in M & R Technology Olympiads and two from non-participating schools were interviewed. The experts and teachers showed that they know what PBL is. They related it to Technology since Technology is about solving practical problems. The experts emphasized the need for teaching Technology through PBL approach, their common reason being the fact that Technology concerns problems that should be solved. The teachers used PBL in their teaching and they also pointed out that PBL is important in the teaching of Technology.

The experts were able to compare teachers and learners from schools participating in M & R Technology Olympiads to their non-participating counterparts by pointing out that those participating were able to apply approaches that stimulate and encourage deep thinking while those who did not participate still resorted to the traditional approaches during lesson presentation, and as a result they suffered diminished enthusiasm.

The teachers indicated lots of thinking skills targeted with the application of PBL. They also pointed out that there was a close relationship between the design process and PBL. The teachers, while indicating the methods and approaches that they found useful, made mention of the fact that the methods they applied are found within PBL. When asked about the benefits for teachers and learners involved in M & R Technology Olympiads, the teachers stated that they exceeded the limits.

During the observations it was evident that learners whose schools participated in M & R Technology Olympiads were attentive in a way that offered them freedom to move around and enjoy their activities. They liked to solve problems. They were also engaged in activities that required them to inquire and ask questions. Their thinking abilities were highly challenged and they operated in ways that sought to make them problem-solvers. They were engaged in the content and sought solutions to explicit problems. They tackled problems heads-on and were not dependent solely on their teachers. The approach used in these schools relied heavily on the PBL approach.

Learners whose schools did not participate in M & R Technology Olympiads, on the other hand, listened attentively and did not question what they were told by their teachers. They seemed to believe that a teacher is always right. The environment in which they found themselves did not allow them enough freedom to think for themselves and to use their thinking abilities accordingly. The approach which was applied in these schools did not resemble PBL as it was advocated by authors in the sources reviewed thus far.

In the next chapter the conclusions of the study are drawn and recommendations regarding the value of PBL for the teaching and learning of Technology are made.

# CHAPTER FIVE

# CONCLUSIONS AND RECOMMENDATIONS

## 5.1INTRODUCTION

In Chapter 4 findings from interviews, observations and document analysis were presented. The objective of Chapter 5 is to round off the study by reflecting on what it has been able to achieve. The reflection hovers on the research questions that were pursued in the study:

- What is problem-based learning?
- Why is problem-based learning a need in the teaching of Technology?
- How do Technology teachers who teach learners that participate in Murray and Roberts Technology Olympiad in Thabo-Mofutsanyana District in Qwaqwa compare with the non-participants in terms of employing Problem-Based teaching?
- How do Technology Education learners who participate in Murray and Roberts Technology Olympiad in Thabo-Mofutsanyana District in Qwaqwa compare with the non-participants in terms of engaging in Problem-Based Learning activities?

The section that follows focuses on the conclusions of the study in relation to the above mentioned research questions.

## 5.2CONCLUSIONS ON THE STUDY

Important conclusions were reached regarding the questions specified in section 5.1 above. These conclusions are as follows:

- PBL is an approach which is based on problems. It is also an approach that requires learners to identify and solve problems; and it assists learners to associate with the problem while learning.
- PBL is a need in the teaching of Technology since Technology is about solving practical problems. Also, PBL is indispensable for teaching Technology because it involves lots of strategies required in achieving the unique character of Technology. The design process in Technology subject can only be approached through PBL; hence PBL is a need in the teaching of Technology.
- Technology subject teachers whose schools participate in Technology Olympiads are able to use teaching strategies and methods that assist to improve the understanding of learners unlike their non-participating counterparts who lack skills to improve the understanding and performance of their learners. It has also been concluded that participating teachers are eager and enthusiastic in the performance of their work and in learning new things while the non-participating teachers are demotivated because their learners struggle to achieve the expected outcomes. The teachers whose schools participate in Technology Olympiads apply approaches that stimulate and encourage deep thinking. It has been concluded; without any shadow of doubt, that the participating teachers apply PBL approach successfully. The views of teachers whose schools participate in M & R Technology Olympiad have led the researcher to conclude that PBL benefits teachers in countless ways such as: understanding the process of learning deeply; treating concepts and theories in depth; increasing the interest and motivation of learners and creating an environment that allows learners to function at an independent and higher level of knowledge construction, acquisition and absorption.
- Conclusions were made regarding the learners who participate in M & R Technology Olympiads and those who do not participate. Learners who participate solve problems and provide solutions to complicated problems with ease. They apply PBL during knowledge creation and knowledge application. The non-participating learners are made to apply an outdated approach to learning; hence they are involved in rote learning and memorization of concepts which is highly discouraged by PBL proponents. The participating learners are ready to face challenges and are more motivated and curious to

learn new things while the motivation and interest of non-participating learners is extremely low. The technological skills such as creativity; problem solving and innovation which are aroused by the application of PBL are lacking for learners who do not participate in Technology Olympiads. The participating learners, on the other hand, apply these skills with ease. A conclusion is therefore made here that PBL is best applied by participating learners.

In the following section a discussion of the aim of this study, which was to investigate the nature of the impact of PBL in teaching and learning of senior phase Technology in Thabo-Mofutsanyana District in Qwaqwa, is attended to.

### 5.2.1 Aim and research problems

This study, as it has been indicated in section 5.2, aimed to investigate the nature of the impact of PBL in the teaching and learning of senior phase Technology**.** The aim and research problems (which were discussed in section 5.2) were investigated as follows:

- A thorough engagement in the literature on PBL was conducted in Chapter 2. Technology teachers from schools participating and non-participating in Technology Olympiad were interviewed and their views were analysed and findings emanated which supported the claim that PBL is the best approach for teaching and learning Technology.
- PBL applied in the teaching of Technology was investigated by interviewing Technology teacher as first-hand implementers of curriculum; indeed their views proved that PBL has an outstanding impact on the achievement of outcomes in the Technology subject. Also, there was an indication that learners who are taught through a PBL approach perform well and also that these competitions make teachers and learners to apply the PBL approach spontaneously.
- The comparison of teachers who teach learners that participate in M & R Technology Olympiads and those teachers who teach learners that do not participate was also used to investigate the aim specified earlier on. The comparison was made by analysing the documents of those teachers and there was a realization that teachers who teach learners

that participate in Olympiads employ problem-based teaching while those that teach learners who do not participate do not employ it. As a result their teaching do not impact positively in the senior phase Technology.

- The same comparison was made between learners who participate and those that do not participate and the nature of the impact of PBL in the learning of Technology favoured the participating learners. A conclusion can thus be made here that PBL has a considerable impact on the teaching and learning of Technology.

The section that follows presents what each chapter in this study addressed and it thus sort of summarise what this study is about.

### 5.2.2 Chapters

Chapter 1 presented the background to Technology Olympiads as a tool for exposing learners to engineering disciplines, giving them the opportunity to enjoy Technology as well as to apply their practical knowledge and skills in finding solutions to real life situations. This chapter also exposed the research problem and outlined the aim of the study. The motivation of the study was also detailed andfinally, the research methodology was discussed.

Chapter 2 presented the literature that was consulted on PBL. It also dealt with Technology and Technology Education as well as technological knowledge and technological processes. The relationship between Learning Aims (within CAPS), Learning Outcomes of TLA and CO's of C2005 was fully detailed in this chapter. The importance of PBL in the teaching and learning of Technology received a dedicated attention in this chapter. The structure ofthe NCS and CAPS fortheTechnology subject as a national policy and its problem-solving character were discussed in detail. Assessment in Technology Education was also fully discussed. Lastly, the role that Technology Olympiads and EXPOS play in the promotion of PBL was discussed.

Chapter 3 focused on the research methodology as well as the population and sample that this study catered for. The chapter also discussed research instruments and the choice for these instruments was fully motivated. The pilot study and its revelations were also presented in this chapter to enable the refinement of the research instruments. Data analysis and trustworthiness of the research instruments (credibility, transferability, dependability and confirmability) were fully explained.

Chapter 4 covered data analysis, interpretation and presentation of findings. Data from the interviews were analyzed and interpreted with reference to research questions and ten research themes. Findings from the interviews were presented in relation to the themes that were used to representthem. Findings from the observations of teaching and learning in participating secondary schools and non-participating secondary schools in M & R Technology Olympiads were also presented. Lastly, documents such as lesson plans, workschedules, Grade 9 learners' portfolios and files were analyzed in order to supplement the more reactive methods such as direct observation with less reactive methods. Mainly the documents were analyzed in order to observe whether PBL was applied and how the application and/or the non-applicationofPBL affected teaching and learning.

This Chapter 5 presents the conclusions drawn on the study, and the aim of the study, which is to investigate the nature of the impact of PBL in teaching and learning of senior phase Technology in Thabo-Mofutsanyana District in Qwaqwa. The summary or overview of the study is discussed by mentioning paragraph by paragraph what each chapter addressed. A brief account about the success of the study as well as challenges of conducting this study is addressed here. Lastly,the recommendations regarding the importance of PBL for Technology teachers and the need to let schools partake in M & R Technology Olympiads to the Department of Basic Education.

The next section presents the success of this study.

### 5.2.3 The success of the study

This study has succeeded to answer the research problem in that PBL has been investigated and found to be the optimum approach for teaching and learning Technology. PBL has been proved to be related to the unique nature of the Technology subject. The reviewed literature indicates that Technology is about solving practical problems and also that PBL assist learners to solve.

Teachers' views have shown that the approach used during M & R Technology Olympiads is PBL. Learners from participating senior phase schools in Technology Olympiads benefit in terms of employing PBL. The study has anticipated that the nature of the impact of PBL in teaching and learning senior phase Technology is overwhelming. The study has succeeded to support this theory through the views of experts and teachers as well as through the observations and document analysis conducted.

### 5.2.4 Challenges of conducting this study

This study faced the following difficulties and limitations:

- A much waited response from the UNISA Research Ethics Committee gave the researcher a feeling that this Committee delayed the completion of the study. Its meetings only once per month contribute to this delay.
- There has been very little research in PBL in South Africa, leading to much struggle in searching the relevant literature.
- Many teachers are not familiar with the contents of the Technology policy documents.
- Observation is seen as a threat by most teachers. Some were uncomfortable to be observed.
- Many teachers do not feel comfortable when their documents are analyzed.
- The interview questions for this study were written in English. For all the respondents English is a second language.
- Researchers should keep the instruments that they use to a minimum to avoid confusion. This study started off with more instruments suggested than the number used ultimately. This would compound confusion and a lack of focus.
- Research skills such as analysis and interpretation of data should be mastered fully before being attempted. The researcher in this study battled to a greater extent at the stages of data collection and analysis.

- The piloting of the interview questions for validity and reliability is quite a challenging task, especially for students that are conducting pilot for the first time.

## 5.3RECOMMENDATIONS

The following recommendations are deemed necessary for an outstanding achievement in the Technology subject and the successful implementation of CAPS by senior phase Technology teachers:

### 5.3.1 Recommendations to Technology teachers

It is recommended that the theory on PBL should be treated extensively during Professional Working Group (PWG) meetings and during workshops organized by the Technology Learning Facilitators. All teachers should be made aware of it and activities should be planned around its application. PBL should be prioritized when discussions about approaches and strategies for teaching Technology are made. PBL should be used by all Technology teachers in all grades. It is recommended that all teachers of Technology should be conversant with the CAPS policy document since a lot of emphasis is placed on the design process therein, also, the fact that miniPATs are compulsory encourages that a PBL approach should be adopted in teaching Technology. It is recommended that during workshops and trainings of Technology teachers an emphasis should be placed on PBL and activities should be designed where teachers learn more about PBL.

### 5.3.2 Recommendations to Department of Basic Education

It is recommended that PBL activities be used to train novice teachers at colleges and universities. Also, it is recommended that a PBL module or chapter be included in the curriculum for Technology Education at colleges and universities so that all teachers of Technology can be made aware of it and be able to apply it with ease. It is recommended that all schools should participate in Technology Olympiads and EXPOS. Technology Olympiads should be compulsory and be part of the curriculum of senior phase Technology subject. PBL should be included in the policy documents of Technology Education as an approach which must be implemented in the teaching and learning of Technology. Learning Facilitators should workshop teachers on PBL. The thinking skills that accompany a PBL classroom should be emphasized in a chapter (in the policy documents of Technology). It is also recommended that the inputs of more teachers (than were used in this study) be considered when discussions about PBL are held.

### 5.3.3 Recommendations for further research

Given the amount of literature reviewed and research on PBL and Technology Education, as well as the findings of this study, further research in the following topics should be considered:

- The relationship between PBL and learner achievement.
- The influence of teacher experience, qualifications, age and gender on the application of PBL.
- Thinking skills and process skills used during the application of PBL in a Technology classroom.
- The effect that the application of PBL has on the cognitive abilities and skills of learners.

## 5.4CONCLUSION

This study investigated the effect that PBL may have on the teaching and learning of Technology. We live in the 21st century and Technology shadows our movements and thinking. Problem-based teaching and learning in senior phase Technology Education requires teachers and all stakeholders involved in education to undergo a mind shift for the betterment of education in South Africa. In highlighting the poor performance of senior phase learners in Technology Education and the impact that this has on the image of our education system, this study aimed to motivate teachers to excel in their work as well as to reach the desired level of teaching in their practice.

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# APPENDICES

## APPENDIX 3.1: REQUEST FOR PERMISSION TO CONDUCT RESEARCH

P. O. Box 18801

Witsieshoek

9870

25 July 2012

The Head of Department

Department of education

Private Bag X20565

Bloemfontein

9300

Dear Sir/Madam

**RE: Permission to conduct research in the province**

I am currently studying for MEd degree in didactics with the Department of Further Teacher Education at the University of South Africa. The study which I wish to undertake concerns the teaching of Technology through a problem-based approach in an outcomes based context.

This study, with its foundation focused in the development of teachers and the Technology subject, is aimed at establishing 'problem-based teaching and learning in senior phase Technology Education'. It is hoped that this study will contribute significantly to the on-going quest to implement CAPS successfully.

It is my wish to conduct the empirical research for this study within the provincial education departments.

Your approval in this regard will be highly appreciated.

Yours faithfully

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Mokoena M. M.

**APPENDIX 3.2: INTERVIEW SCHEDULE FOR FACILITATORS AND JUDGES**

Please answer the following questions in the space provided:

1. What is Problem Based Learning (PBL)?

______________________________________________________________

______________________________________________________________

2. How is Problem Based Learning (PBL) related to technology subject?

______________________________________________________________

______________________________________________________________

______________________________________________________________

3. Why is Problem Based Learning a need in the teaching of technology subject?

______________________________________________________________

______________________________________________________________

______________________________________________________________

4. How do technology subject teachers who teach learners that participate in Murray and Roberts Technology Olympiad in Thabo-Mofutsanyana District Qwaqwa, compare with the non-participants in terms of employing Problem Based Learning (PBL)?

______________________________________________________________

______________________________________________________________

______________________________________________________________

5. How do technology subject learners who participate in Murray and Roberts Technology Olympiad in Thabo-Mofutsanyana District Qwaqwa, compare with the non-participants in terms of employing Problem Based Learning (PBL)?

______________________________________________________________

______________________________________________________________

## APPENDIX 3.3: ORAL INTERVIEW QUESTIONS FOR TECHNOLOGY TEACHERS

1. How can you explain problem-based learning?
2. Do you use problem-based learning in your teaching of Technology, why?
3. Why is problem-based learning important in the teaching of the Technology?
4. What thinking skills do you target in learners with problem-based learning?
5. What is the relationship between design process and problem-based learning?
6. Which other methods and approaches do you find useful to teach Technology subject?
7. How often do you use these methods and approaches compared to problem-based learning in Technology?
8. Thinking of problem-based learning, what are the benefits of participating in Murray and Roberts Technology Olympiad? [for teachers whose schools participate in this project].
9. Thinking of problem-based learning, how could your learners benefit if your school participated in the Murray and Roberts Technology Olympiad?

**APPENDIX 3.4 RESEARCH ETHICS CLEARANCE CERTIFICATE**

UNISA college of education

# Research Ethics Clearance Certificate

This is to certify that the application for ethical clearance submitted by

**MM Mokoena (4574 3118)**

for a M Ed study entitled

**Problem-based teaching and learning in senior phase technology education in Thabo-Mofutsanyana District, Qwaqwa**

has met the ethical requirements as specified by the University of South Africa College of Education Research Ethics Committee. This certificate is valid for two years from the date of issue.

Prof CS le Roux
CEDU REC (Chairperson)
lrouxcs@unisa.ac.za

2 October 2012

Reference number: 2012 SEPT/ 45743118/CSLR