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IMPLEMENTING A PROBLEM-BASED LEARNING MODEL IN THE TRAINING OF TEACHERS FOR AN OUTCOMES-BASED TECHNOLOGY CURRICULUM

by

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Our underlying frames, gestalts, paradigms, big pictures are everywhere in doubt. The task is to understand how we acquire frames, how we communicate them, and how we change them in ourselves and others - Peter Vail.

The significant problems we face cannot be solved at the same level of thinking we were at when we created them - Albert Einstein.

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LIST OF ACRONYMS AND ABBREVIATIONS

ABET	Adult Basic Education and Training
ANC	African National Congress
C2005	Curriculum 2005
CEPD	Centre for Education Policy Development
CERI	Centre for Educational Research and Innovation
CFC	Consultative Forum on Curriculum
CUMSA	Curriculum Committee for South Africa
ECD	Early Childhood Development
ETDP	Education, Training and Development Practitioners
ETQAs	Education and Training Quality Assurers
FET	Further Education and Training
FETC	Further Education and Training Certificate
FRD	Foundation for Research Development (South African)
GET	General Education and Training
GETC	General Education and Training Certificate
HEDCOM	Heads id Education Department Committee
HETC	Higher Education and Training Council
HSRC	Human Sciences Research Council
IEA	International Association for the Evaluation of Educational Achievement
IEB	Independent Examinations Board
INSET	In-service Education and Training
LSEN	Learners with Special Education Needs
NEPI	National Education Policy Investigation
NGOs	Non-governmental Organisations
NICD	National Institute for Curriculum Development
NILLD	National Institute for Lifelong Learning Development
NQF	National Qualifications Framework
NSBs	National Standards Bodies
NSF	National Science Foundation (American)
NTB	National Training Board
NTT	National Task Team

OBE	Outcomes-Based Education
OECD	Organisation for Economic Co-operation and Development
PBL	Problem-based Learning
PRESET	Pre-service Education and Training
PTT	Provincial Task Team
RDP	Reconstruction and Development Programme
RPL	Recognition of Prior Learning
SACATE	South African Council for the Accreditation of Teacher Education
SAQA	South African Qualifications Authority
SGBs	Standards Generating Bodies
STS	Science Technology Society
TIMSS	Third International Mathematics and Science Survey

GLOSSARY OF WORKING TERMS

In this thesis, the following meanings are assigned to key terms, consistent with their current use in South Africa.

Accreditation — A procedure by which an authoritative body gives formal recognition that an institute, body or person is competent in terms of a specific purpose.

Applied competence — Is the combination of a learner's demonstrated ability, in an authentic context, to consider a range of possibilities for action (practical), and based on an understanding of the underpinning knowledge and thinking (foundational), to adapt to changing unforeseen circumstances (reflexive).

Assessment — The process of collecting and interpreting evidence of learner achievement.

Assessment criteria — The criteria included in a unit standard to determine the achievement of specific and critical outcomes.

Competence — The capacity for continuing performance within specified ranges and contexts, resulting from the integration of a number of specific outcomes.

Core learning — The specific core knowledge, skills and attitudes required for the completion of a particular qualification i.e. the required specialism for the purpose of the qualification.

Credit — The recognition by an accredited body that a learner has satisfied the outcomes of a unit of learning expressed as a credit value at a specific level. Credits may be accumulated until conditions for a qualification have been met.

Curriculum framework — The philosophical and organisational framework for a specific curriculum.

Curriculum 2005 — The renewed curriculum framework for compulsory school years (Grade 1 through 9) and which was said to be based on transformation OBE principles. Curriculum 2005 specifies the 66 specific outcomes for the eight Learning Areas, together with the assessment criteria and range statement for each specific outcome. The 2005 is a time frame label indicating that the new curriculum framework had to be phased in all grades up to grade 12 by the year 2005.

Elective learning — Optional credits within a formal learning programme that may be of personal interest or professional relevance, or that open the door to a range of possible career and vocational choices.

Evaluation — The process whereby the information obtained through assessment is interpreted to make judgements about a learner's competence.

Integration of education and training — The human resource development policy rejects the rigid division between "academic" and "applied", between "theory" and "practice" and between "knowledge" and "skills" in order to avoid the past perception that education possessed higher academic status than training. Both have equal status and importance.

Learning Area — It represents a broader knowledge field which is informed by the commonalities it shares with other areas of learning which ensure that fragmented views of learning are counteracted. Learning programmes will be developed which integrate learning experiences from various Learning Areas.

Lifelong learning — Ongoing learning through a continuous supportive process that stimulates and empowers individuals to acquire and apply knowledge, values, skills and critical understanding, required to respond confidently and creatively and to rise to the challenges of a changing social, political and economical environment.

Outcomes-based education — A learner-centred, result-orientated approach based on the belief that all learners can learn and succeed. It implies that learning institutions control the conditions for success. Curriculum design starts from a clear definition of the significant learning that learners have to achieve – all decisions about instructional strategies, learner assessment and organisation of the learning environment are linked directly to the outcomes that learners have to demonstrate.

Problem-based learning — Is the learning that results from the process of working. toward understanding or resolution of a problem. The problem is encountered first in the learning process and serves as a focus or stimulus for the application of problem-solving or reasoning skills, as well as for the search for information or knowledge needed to understand the mechanisms responsible for the problem and how it might be resolved. It also implies a curriculum design approach where the outcomes are organised around problems. PBL also implies a particular strategy for facilitating learning.

Programmes — A planned combination of learning outcomes, which results in credit accumulation towards the achievement of a qualification.

Technology education — Concerns the technological knowledge and skills, as well as the technological processes, and involves understanding the impact of technology on both the individual and society. It is ultimately designed to promote the capability of and to stimulate learners to contribute towards problem-solving.

SUMMARY

Since the democratic elections in South Africa in 1994, the socio-political transformation impacted on the paradigms that are evolving in education and training in two important ways – it introduced a new philosophical base for education and training, and it established new systemic structures for organising and managing education and training. These reforms were based on a vision of lifelong learning for all South Africans and both the philosophical base and structures for its implementation were based broadly on the concept of transformational outcomes-based education. Introduction of this new paradigm set in motion a process of curriculum reform across all fields of education and training. For the years of compulsory schooling, the new curriculum framework was known as Curriculum 2005. This structure divided the school curriculum into eight Learning Areas, one of which was called Technology and that was never previously presented in public South African schools.

The realities of a new paradigm and a new Learning Area compelled teacher educators to design new programmes and methodologies to prepare prospective and in-service teachers for the daunting task of teaching. This research focused on preparing pre-service final year high school teachers in the natural sciences to facilitate learning in technology from an outcomes-based perspective. This research explored problem-based learning (PBL) as a curriculum design type where the entire curriculum of a particular course is organised around problems and as a strategy to be used for training the pre-service teachers. The rationale for using PBL is the following:

- It is a strategy which has the potential to operationalise OBE principles in learning environments.
- It is a strategy which enhances the transferability of competence from university classroom to the real workplace, because of its embedded characteristic of authenticity.
- The syntactical nature and structure of PBL and technology education show strong similarities.

The outcome of the literature review was the development of a model called the OBE-PBL model. This model was implemented on two levels. First, it was used during the six month training of the pre-service teachers and second, the pre-service teachers had to implement this model when they had to facilitate learning in technology education in real schools for one month. Quantitative data were gathered to determine how successful the pre-service teachers were in transferring their competencies gained through the OBE-PBL model in the authentic situation. The pre-service teachers taught the control groups in the schools according to the traditional instructional paradigm, while the experimental groups were taught according to the OBE-PBL model. Pre- and post-test, as well as experimental and control group comparisons were conducted to determine whether statistically significant differences were present and what the nature of these differences were. Data of a qualitative nature were gathered from learners, as well as through interviews with the pre-service teachers about their OBE-PBL training and classroom experience of implementing it.

The results showed that the pre-service teachers transferred their OBE-PBL competencies to such an extent that the post-test results of the experimental group were significantly better than their pre-test results. The post-test results of the experimental group were not significantly better than the post-test results of the contol group. However, the experimental group learners performed significantly better in higher cognitive questions that demanded meta-cognitive skills. Pre-service teachers indicated that the complete OBE-PBL experience was challenging but valuable, and one said that she has learnt the most in this course than she had learnt the whole year. The practice experience highlighted that some had a narrow view of their role as an OBE facilitator of learning in a PBL environment. After an in-depth reflection on all the dimensions of the findings, particular recommendations are made on how to develop and refine the OBE-PBL model further to enhance its suitability and impact on the training of pre-service teachers for technology education.

OPSOMMING

Sedert die demokratiese verkiesing in Suid-Afrika in 1994 het die sosio-politiese transformasie 'n direkte impak gehad op die paradigmas wat tans besig is om te ontvou in onderwys en opleiding op twee vername wyses – 'n nuwe filosofiese grondslag is bekengestel, asook 'n nuwe sistemiese struktuur wat verantwoordelik is vir die organisasie en bestuur van onderwys en opleiding. Die hervormingsinisiatiewe word aangedryf deur 'n visie van lewenslange leer vir alle Suid-Afrikaners en is gebaseer op die beginsels van

transformatiewe uitkomsgebasserde onderwys (UGO). Vir die verpligte skoolfase het die vernuwingsinisiatiewe gekulmineer in a kurrikulumraamwerk genaamd Kurrikulum 2005. Volgens hierdie raamwerk word die kurrikulum in agt Leerareas verdeel, waarvan Tegnologie een is wat nog nie vantevore amptelik in publieke skole aangebied is nie.

Die realiteite van 'n nuwe paradigma en Leerarea het onderwyseropleiers genoop om voor- en indiensprogramme te herkonseptualiseer en nuwe metodologieë te eksploreer om onderwysers toe te rus vir hul groot opgaaf. Hierdie navorsing het daarop gefokus om voornemende hoërskool onderwysstudente voor te berei om leer te fasiliteer in tegnologie-onderwys vanuit 'n uitkomsgebaseerde perspektief. Probleemgebaseerde leer (PBL) is geëksploreer as 'n kurrikulumontwerpbenadering waar probleemscenario's gebruik word om die kurrikulum te organiseer, asook 'n opleidingstrategie vir die onderwysstudente. Die rasionaal vir die implementering van PBL is die volgende:

- Die strategie het die potensiaal om UGO-praktykbeginsels te oprasionaliseer.
- As gevolg van die outentieke karakter van PBL kan bevoegdhede wat tydens opleiding ontwikkel word effektiewer oorgedra word na die werksplek.
- Die sintaktiese struktuur van PBL en tegnologie-onderwys toon sterk ooreenkomste.

Die uitkoms van die literatuuroorsig was die konstruksie van 'n model genaamd die UGO-PBL model. Hierdie model is op twee vlakke geïmplementeer. Eerstens is dit gebruik vir die ses maande opleiding van die onderwysstudente en tweedens moes hulle die model implementeer tydens die fasilitering van leer in tegnologie vir een maand in skole. Kwantitatiewe data is ingesamel om vas te stel hoe effektief die onderwysstudente hul bevoegdhede kon oordra na die praktysituasie. Die kontrolegroepe is onderrig volgens 'n tradisionale instruksie-transmissiemodel, terwyl die intervensies met die eksperimentele groepe op die UGO-PBL model gebaseer was. Kwalitatiewe data is vanaf leerders verkry, asook vanaf ondehoude wat met die onderwysstudente gevoer is oor hul UGO-PBL opleiding en praktykervaringe.

Die resultate het getoon dat die onderwysstudente hul UGO-PBL bevoegdhede sodanig oorgedra het dat die natoets van die eksperimentele groep beduidend beter was as hul voortoets. Die natoets van die eksperimentele groep was egter nie beduidend beter as die natoets van die kontrolegroep nie. Alhoewel, in sekere vrae wat as hoë kognitiewe vrae geklassifiseer was en wat meta-kognitiewe vaardighede vereis het vir beantwoording

daarvan, het die eksperimentele groep beduidend beter presteer. Die onderwysstudente het aangedui dat die omvattende UGO-PBL ervaring uitdagend en waardevol was en een het gemeld dat sy meer in hierdie kursus geleer het as in enige ander kursus gedurende die jaar. Data wat verkry is vanaf die praktykimplementering het egter getoon dat sommige onderwysstudente 'n verskraalde persepsie gehuldig het oor hul rol as UGO leerfasiliteerders in 'n probleemgebaseerde leeromgewing. Na afloop van deeglike refleksie op die veelvuldige dimensies van die bevindinge, word aanbevelings gemaak oor hoe om die model the verfyn sodat die geskiktheid en impak daarvan op die opleiding van tegnologie onderwysstudente kan verhoog.

CHAPTER 1

GENERAL INTRODUCTION, STATEMENT OF THE PROBLEM AND OVERVIEW OF THE STUDY

1.1 Introduction

The global and local societies we live and work in are transforming at an intense rate and in ways often not anticipated or even imagined. Paradigms guiding our thinking and doing have to be fluid in that they freeze, unfreeze and reorganise to adapt to the diverse and multiple flexible needs and demands of a post-modern world. The field of Education and Training is by no means an exception to this volatile reality and finds itself in the midst of transformation, particularly in South Africa.

Following the 1994 elections, South Africa embarked on a programme of social and economic reform that is officially referred to as the Reconstruction and Development Programme (RDP). The key purpose of the RDP is to set in motion structures and mechanisms that will promote the redress of inequalities left behind by the legacy of non-democratic governance prior to 1994. A key component of the RDP is the transformation of the education system. The education transformation agenda in terms of its organisational, legislative and governance frameworks, which were put in place during 1995, is underpinned by the following principles (Department of Education, 1999:18-19):

- **Equity and redress**, especially in the equitable provision of finances and resources.
- **Access** to basic education for all.
- **Quality** in terms of providing learners with learning opportunities of an acceptable standard.
- **Efficiency**, to ensure optimal value for the considerable financial and other resources which are invested in education.

- **Democratic participation** in the governance and management of education institutions and the sub-system as a whole.

- **Sustainability** of development initiatives, so that they will contribute to overall transformation in the long term.

- **Relevance** of education to the needs of the economy and individuals' vocational aspirations, as well as broader social and cultural values.

The following paragraph from the White Paper on Education and Training (1995:15) highlights the objectives of transformation in South African education and training:

> *Successful modern economies and societies require the elimination of artificial hierarchies, in social organisation, in the organisation of and management of work, and in the way in which learning is organised.*
>
> *They require citizens with a **strong foundation of general education**, the desire and ability to continue to learn, to adapt to and develop new knowledge, skills and technologies, to move flexibly between occupations, to take responsibility for personal performance, to set and achieve high standards, and to work co-operatively (Own bold print).*

At school level, the transformation gained impetus when the Minister of Education announced an important public milestone on March 24, 1997 – the launch of Curriculum 2005. Curriculum 2005 is the framework for reform of the school curriculum and was proposed to be phased in from grade 1 through 9, which constitutes the general education phase referred to in the White Paper. The initial intention with Curriculum 2005 was that by the year 2005 the new curriculum would be implemented across the first 9 years of schooling. The educational reforms in Curriculum 2005 and all other forms of education and training in South Africa, are built on the vision and principles of **outcomes-based education** (OBE).

One of the key aspects of the outcomes-based Curriculum 2005, is that learning will be organised in eight Learning Areas, rather than in traditional subjects. One of the Learning Areas that came into existence with Curriculum 2005 is **Technology**. The introduction of

OBE in general, and the introduction of technology education in particular, has created the need for teachers to develop a new philosophy about teaching and learning, as well as a range of new teaching competencies. It is expected that teachers will learn about the new paradigm and obtain new competencies through pre-service and in-service teacher education programmes.

The term "teacher education" will be used when reference is made to the overarching programme associated with a whole qualification. The term "teacher training" will be used when reference is made to a sub-programme within the qualification programme. In South Africa, part of the transformation policy promotes the integration of education, which used to be more academically orientated, and training, which was vocationally orientated (French, 1997:17-31). French continues to explain that the principle of integration *"is a political strategy to ensure foundational structures that will never allow an easy slippage back into the class system, the privileging/marginalising that happens in the split between education and training"* (1997:19). Within the spirit of the transformation, it seems that these two terms may be used interchangeably in the South African context.

This thesis describes research that investigated one way of empowering teachers to meet the new challenges of teaching technology in particular, but also physical science and other Learning Areas within an OBE framework. The research was conducted in two contexts: first, within a pre-service education programme designed to provide pre-service teachers with the knowledge and skills necessary to teach about technology through a **problem-based learning (PBL) curriculum and strategy;** second in authentic school classrooms where the pre-service teachers attempted to apply their newly acquired competencies.

To provide a background for this research, some key issues related to technology, technology education and teacher training in this area according to the new paradigm, are identified in the following sections of this chapter. This leads to the formulation of the research problem and research questions which will direct the rest of the research. The final sections of this chapter will briefly summarise the proposed research design and methods. The last section will also sketch the preliminary significance of this research in the field of pre-service teacher training in South Africa.

1.2 The importance and impact of technology on the global and local society

The impact of inventions, discoveries and creative innovations of technology, integrated with science and mathematics, are apparent in all spheres of life. The fast expanding realm of technology is one of ever increasing importance in the information age. Technology is acknowledged by most as the single most powerful driving force in the world, since it penetrates every aspect of work, play, private and public life.

Countries who want to do more than survive now and in the future, who want to lead and compete in the global economical environment, are also dependent on technological prosperity and the technological capabilities of their people. This relationship between technology and economic-prosperity was emphasised by President Clinton in 1993 when he introduced his technology policy as follows:

> *Technology is the engine of economic growth. In the United States technological advance has been responsible for as much as two-thirds of productivity growth since the Depression. Breakthroughs such as the transistor, computers, recombinant DNA and synthetic materials have created entire new industries and millions of high paying jobs. ... Investing in technology is investing in America's future: a growing economy with more high-skill, high-wage jobs ...and an inspired scientific and technological research community focused on ensuring not just our national security but our very quality of life* (Dyrenfurth, 1995:2).

This link between technology, economic growth and the overall development of a country is a common driving force for educational reforms. For example, it was central to the political arguments that drove education reform in Australia in the early 1990's (Killen, 1998a) and it is a key issue in South Africa's current educational reforms (National Education Policy Act, 1996).

Referring to the role to be played by technology, Shield (1996) remarked that technology in the modern world provides a self-fulfilling imperative, in that all citizens of a modern state should know all about and understand the role of technology. Only by becoming a life-long learner in the field of technology, will people function effectively in societies which are technologically driven.

The American National Science Foundation (NSF) pointed out that traditional curricula, especially traditional science and mathematics, are inherently not suited to develop the technological capability of their youth. They said that "... *literacy standards for twenty-first century society are expanding beyond the traditional three R's into science and technology*" (NSF, 1983: August 3). Learners will need more than the body of knowledge and skills provided by traditional science which has been practiced world-wide from a positivist world view as a value free endeavour. Yager (1995:18) contends that *"students in science classes are more knowledgeable about technology than they are of basic science concepts and processes ... technology provides a tie to most current problems and can provide the link between science and peoples' lives"*. The "technologization" of science is promoted by Kahn & Volmink (1997:7) as a practical means of revitalising the school science curriculum and addressing the gap in technology education.

It is often argued that if South Africa is serious about reducing poverty, unemployment and all the negative social effects associated with them, it must seriously become competitive in the global economy, drawing on a technological literate and highly skilled work force (ANC, 1994). Ntuli, then chairman of the national technological career development agency PROTEC's Executive Committee, reinforces this argument when he concludes that "*unless we invest in improving the pool of technologically skilled South Africans, we will not recover fully from this or any subsequent recession...We must develop a strong, world class technology base to generate jobs and wealth needed to sustain our people*" (1992:3). It is necessary to realise and embrace the urgent importance of technological enhancement as the base of economical prosperity and global competitiveness. It is just as necessary to realise and embrace the fact that the **education system**, formal or non-formal, stands at the base of economical prosperity, since it is the route to employment of an appropriately educated and skilled workforce.

The Organisation for Economic Co-operation and Development (OECD) acknowledges the vital role to be played by education. To realise their primary vision of developing the world economy, the OECD founded as one of their initiatives the Centre for Educational

Research and Innovation (CERI) in June 1968. The main objectives of this educational centre are:

- to promote and support the development of research activities in education and undertake such research activities where appropriate;
- to promote and support pilot experiments with a view to introducing and testing innovations in the educational system;
- to promote the development of co-operation in the field of educational research and innovation (Black & Atkin, 1996:i).

None of the policies or objectives of the OECD specifically mention mathematics, science or technology education. However, in 1989 when the OECD group started a six-year educational research study, the situation analysis pointed to a common need in all the different countries:

> *The fields of mathematics, science and technology called for new innovations to be planned, orchestrated, implemented and evaluated, because educational change in (these) subject areas are vital to every country's future* (Black & Atkin, 1996:2).

This initiative by the OECD once again acknowledges the fact that the future of nations will increasingly be built in the classrooms of those nations. It is here that beliefs, essential understandings, personal career ideals and capabilities are cultivated which will advance the economy, society and the individual. Only as recently as the mid-nineties has technology education, also known by other names, invented itself in the national curricula of different countries in the world. The following paragraphs will trace the roots of technology education in different national curricula.

1.3 International and national perspectives on technology education

Substantial insight can be gained and lessons learnt from international endeavours and experiences with a relatively new Learning Area in curriculum, technology education. Technology education is offered in more than 50 countries in some way or another in school curricula. Different social, political, financial and historic-cultural considerations have determined how technology education was conceptualised, designed and implemented in different countries varying from developed to developing countries.

The justifications for including technology in different national curricula ranged from broader attitudinal ones seeking to value the practical, to attempts to promote economic competitiveness, to some pure educational ones focusing on the technological design process which might enhance problem-solving skills. By reviewing some of the international trends, it is possible to place South African educational reforms in this field, into a broader context. The section to follow will highlight some international trends, but it is not meant to be comprehensive. It will, however, where applicable make special mention of problems or initiatives experienced with pre- or in-service teacher education, since this study has an interest in this field.

1.3.1 International perspectives on technology education

In many countries, technology, unlike subjects such as physics, chemistry, biology and earth sciences, does not have a long history and the same status as these subjects. Only during the past decade have several options emerged to deal with technology in primary and secondary schools. Three basic options have emerged in different schools in various countries. The first option is to introduce technology as a new subject into the curriculum. A second is to add technological topics to the science curriculum. A third option is to develop science, technology and society (STS) courses to replace, or be added to science courses (Medway, 1989 and Layton, 1993).

In the *Netherlands*, technology was introduced in 1993 as an obligatory subject for all learners in junior secondary schools (Black & Atkin, 1996:57-58 and Eijkelhof, Franssen & Houtveen, 1998:677). This initiative was chosen to be the Dutch contribution to the OECD Science, Mathematics and Technology Education Project. Prior to 1993, a pure craft orientated version of technology was in use in their vocational schools. Some of the schools still prefer to take the craft-vocational route. The new subject, technology, had a variety of aims which can be summarised as follows (Eijkelhof, Franssen & Houtveen, 1998:679):

- Familiarising pupils with technology to
  - be prepared for further technical studies;
  - function effectively in society;
  - understand technologies of particular cultures (indigenous technologies).
- Learners acquire knowledge and understandings in the three main pillars of technology (energy, matter and information) and in close relationship with natural sciences and society in order that
  - they can become actively involved in producing technology and innovations;
  - they can learn to use technological products;
  - they can explore their abilities and interests in the field;
  - boys and girls are offered equal opportunities.

For the Dutch secondary schools, the Dutch Technology Teachers' Association, together with allies from industry and academic fields also proposed to launch technology as a separate subject (Van Aalst, 1995). This proposal did not receive much support. Instead it was decided to integrate technology into subjects such as mathematics, chemistry, physics, biology and general sciences. Apart from the integration some technological skills have been added to the science curriculum, such as

- recognising a technological problem;
- developing a design;
- constructing based on this design;
- evaluating this design and the construction process;

- making proposals for improving the design.

The OECD/SMTE study results showed that one of the problems which will have to be conquered when integrating science and technology is the lack of co-operation and communication, due to competition between science and technology teachers. A solution suggested, is to create a single science and technology department with one head, who should be responsible for co-ordination across the curriculum and who could negotiate with administrators and local industries on behalf of the whole department (Eijkelhof, Franssen & Houtveen, 1998:689).

In 1988 *British* Parliament passed the Education Reform Act that created their National Curriculum which also accommodates technology as a separate subject. The structure of their curriculum consisted of four key stages of compulsory education for years 5 to 16. The curriculum consisted of core subjects, i.e. mathematics, science, English and foundational subjects, where technology was included. It was decided that this new subject would be known as "design and technology" to emphasise the interconnectedness of these two concepts (Barlex, 1992:20). The new subject intends to bring together several curriculum areas which were previously taught separately.

According to Stables (1996) one of the major needs and problems with the implementation of this new foundational subject was that very few of the teachers who had to teach design and technology received formal training in the teaching of the subject. The rapid introduction of this new subject meant that teachers from home economics, business economics, science, art, craft and design were called upon to teach this subject. Currently there is a back-log of unprepared technology teachers teaching this subject and this has led to a lack of cohesiveness and sometimes negative experiences with the subject.

It would appear then, according to Barlex (1992:24), that to help teachers to move forward in this subject, considerable in-service training is required and it should focus on

- developing teachers' conceptualisation of technology;
- developing their confidence in their ability to build creatively on their previous experience in other subjects;

- providing teachers with personal hands-on technological experiences and the opportunities to share it with colleagues before they try it out with learners.

In *Israel* the subject "Integrated Technology" was introduced as a junior high school subject in 1994 and the new "Integrated Science and Technology" was introduced in intermediate schools in 1996 (Verner, Waks & Kohlberg, 1997). Integrated Technology in senior high school beyond grade 10 is not compulsory. The curriculum is divided into general, technological, vocational and religious bands. Currently, the technological schools provide education to approximately half of all secondary learners. Subjects which learners may choose from in technological schools include electronics, machinery, specialisation in computers and agriculture.

In *Australia,* approaches to technology education vary from state to state. As an example, in the state of New South Wales, technology education is a component of the Science and Technology Learning Area in the K-6 syllabus. In 1996 an evaluation was undertaken of the Science and Technology K-6 syllabus and the Support Document (Board of Studies NSW, 1995-1997). The evaluation involved 38 primary schools throughout New South Wales, 555 teachers and 38 principals were interviewed. Cognisance may be taken from the following conclusions from the research results (Board of Studies NSW, 1995-1997):

- The technology component was not fully understood by teachers at the time of the evaluation and seems to have a "mid-range" status.

- Curriculum integration with content from English and/or Human Society and Its Environment was very common.

- Programmes tend to favour content relating to natural and physical sciences (living things, physical phenomena, the earth and its surroundings) and it appears that less emphasis is given to technology units (products and services, information and communication).

- As a result of the issues mentioned in the previous point, priority is given to the process of investigation and less to designing, making and using technology.

- Teachers recognise the need for ongoing professional development in Science and Technology and require support especially in the following areas:

  - Accessing supplies of consumable resource materials.

  - Curriculum integration units with English, Human Society and Its Environment.

  - Background information on science and technology concepts.

At the secondary school level, technology is part of the Technology and Applied Studies Learning Area. Design and Technology is a subject within this Learning Area and is compulsory for learners in years 7 and 8. In years 9 and 10 learners can select other technology related subjects.

In the early years (1989-1992) of the introduction of technology education in Australian schools, the major problems were the limited in-service training of specialised teachers, and the reluctance of teachers to embrace the new methodologies of teaching associated with the teaching of technology. The new types of methodologies referred to are learner-centred, experiential-based learning, as well as enterprise learning which is learner defined and orientated towards problem-solving, meeting needs, discharging responsibility and centred around real projects (Morgan, 1992:133-134). The secondary schools which implemented technology education successfully in the early years of 1987 in Western Australia, contributed their successful implementation to continuous co-ordination, monitoring and assistance for technology teachers by an on site technology co-ordinator who had enough time to manage the implementation and drive the process. The funding for the on site technology co-ordinator was originally provided by the Ministry of Education and not by the individual schools (Treagust & Rennie, 1990).

In the *United States of America* it is proposed that technology be integrated in the science and mathematics curriculum. Three projects have been initiated which proposed models for science and technology education. Two of the projects, *Educating Americans for the 21st Century* (1983) and *Project 2061* (1983) came from the science fraternity namely the National Science Foundation (NSF), while the project *A Conceptual Framework for Technology Education* (1983) came from technology educators. These projects were set up in 1983 in an effort to regain the USA's technological lead over the rest of the world. As was the case in the United Kingdom, the best school learners in the USA compared well to those in Japan, but the majority (90%) at that time performed much worse than the majority of learners in Japan (McCormick, 1992:40). These initiatives were also stimulated by the concern with the poor performance of learners compared with those in Japan in international tests, such as the Third International Mathematics and Science Study (TIMSS) which was written in 1995-1996.

This concern called for constructive inputs resulting in the NSF and NASA funding a project called *Technology for All Americans* (NSF, 1983). A panel of experts in science, technology, mathematics, engineering and technology education, developed standards for a technologically orientated curriculum. The standards were developed around the notion of technological needs for school-to-workplace articulation, technological literacy for all and the need to provide education for those interested in advanced technological careers.

Canada decided on a *technology-across-the-curriculum* approach. Chinien, Oaks & Boutin, (1995) found in their research, that there was a need to integrate technological literacy across school curricula from K-12. It was also advised that technology should be integrated into all grade levels and all subjects, beginning in kindergarten, from very traditional technology to emerging sophisticated technology. An evaluation report stated that while technology was implemented on a large scale in Canadian schools, only 50% of the teachers had some type of retraining intervention in technology. This failure to provide adequate teacher training in technology education, it is warned, may have a devastating impact on the implementation of technology education, since teachers are the main change agents of any curriculum (Chinien, Oaks & Boutin, 1995).

In *Africa, Botswana* has implemented the "Design and Technology" approach from the United Kingdom. Most of the African countries have implemented technology within the context of integrated science and vocational studies, which is also mainly the trend in the Pacific rim where the entire education is more vocationally orientated (Kahn & Volmink, 1997:5-6). The reason, it is speculated, is that in most developing countries the main objectives with technology, which is actually more technically orientated, is to stimulate learners' interest in technical careers. By doing this learners are prepared with pre-vocational skills and attitudes required for work in industry, agriculture and other production sectors.

The trend in the rest of Africa is to reinstate the traditional, sometimes called indigenous, technology that has always existed – a technology associated with the improvement of the environment and habitat, with handicrafts, peasant trades and farming techniques. The purpose for doing so is not to oppose the imported modern technology. It is rather done to develop appropriate technology which can build a bridge between the traditional technology and sophisticated industrial and information technology, which is unsuitable to the predominantly agricultural societies on which it is imposed (Unesco,1983).

This brief overview indicates several distinct approaches to technology curricula and the implementation thereof in various countries. It also highlights several common problems which should be avoided and used as lessons to learn from for future implementation of this Learning Area. The most important problems seem to have been a lack of clarity in the definition of technology education and the conceptualisation thereof within a particular country's context. Another major problem is the failure to provide adequate in-service training for teachers who had to be retrained for technology education. These issues will now be examined within the South African context.

1.3.2 National perspectives on science, technology and mathematics education

1.3.2.1 Problems and difficulties facing mathematics, science and technology education in South Africa

The terrain of science, mathematics and technology, as well as education in these areas, have been researched and investigated in detail by various studies over the past years in South Africa. A key issue which proved to be problematic for decades now, is the high proportion of un- or under-qualified teachers on whose shoulders lie the responsibility for the nation's education in these areas. Another threatening problem is the inadequate supply of teachers in these subject areas (Kahn, 1994). Approximately 1350 secondary school mathematics and 1000 secondary school science teachers qualified in 1996 with some form of qualification, such as an advanced certificate, diploma or degree with specialisation in teaching in these subjects. Approximately one quarter of the qualified mathematics and science teachers altogether, hold a university degree (EduSource, 1997:2-3). These numbers are not nearly enough to cater for the educational needs in these areas as will be seen when the attrition rate is discussed later in this section.

An analysis of the number of students currently registered in mathematics and physical science related subjects at tertiary institutions, geared towards education, indicates that there will not be a significant increase of teacher numbers entering the schools over the next three years (EduSource, 1997:3). The attrition rate is significant for determining the number of teachers who need annually to enter the profession to balance the number leaving. The average attrition rate in all subjects, across primary and secondary schools, is 6%. In mathematics and science, the rate of 15% is far higher than the overall average. One reason for the high attrition rate of mathematics and science teachers is the fact that there are several other employment opportunities with much more attractive salaries outside of the teaching profession.

The average class size in these subjects is often greater than 40. If this number is to be reduced, even more teachers will be needed. It was also estimated that for the period 1997-1999 the annual deficit would be approximately 3000 mathematics and 3600 science teachers. That is to meet the targets of decreasing class size and improving the annual attrition rate. In this same period the output of qualified mathematics teachers was approximately half of the number needed to replace the annual attrition rate of 15%. In science the situation looked worse, where the output is only 40% of the number of science teachers required to replace the annual attrition rate (EduSource, 1997:3-4).

As early as 1981 the expansive National De Lange Investigation on Educational Provision (HSRC, 1981:45) came to the following conclusion:

> *The great demand for persons who are trained in Mathematics, Physics, Chemistry, Mechanics and Electronics or who have anything from an elementary to an advanced knowledge of these subjects necessitates that the current high drop out rate in these subjects should be considered afresh. From a curriculum perspective it would appear that attention should be paid to curriculating for* ***Functional*** *Mathematics, Physics, Chemistry, etc.* (Own boldprint).

still exists. Against the background of this picture the White Paper on Science and Technology (1996) argues that government has the responsibility to promote these areas and to provide incentives for disadvantaged groups to study mathematics and science and to achieve computer literacy, as well as to put a national system of innovation in place.

A recent research report sponsored by the Danish International Development Agency on *the Demand, Utilisation, Supply and Training of Science and Mathematics Teachers* (1997) actually mirrors the problems and findings of the De Lange Investigation.

The report *"Mathematics and Science Teachers: Demand, Utilisation, Supply, and Training in South Africa"* (EduSource, 1997) reports extensively on the findings regarding the utilisation, demands, qualifications and teacher-learner ratios in all the different provinces in South Africa. It must be noted that when this research was undertaken, technology education had not yet been implemented in South African schools. The enormity of the problem is highlighted by data that summarise the qualifications of science teachers (Table 1.1) and mathematics teachers in South Africa (Table 1.2):

Table 1.1 Qualifications of teachers in science across the provinces in South Africa

Subject Qualification	Teachers qualified in science	% of total science teachers (n = 14 107)
Three or more years university course	1 192	8 %
Two-year university course	360	3 %
One-year university course	701	5 %
Higher Diploma of Education (science)	427	3 %
Secondary Teacher's Diploma (science)	3 208	23 %

Subject Qualification	Teachers qualified in science	% of total science teachers (n = 14 107)
Total Qualified	**5 889**	**42 %**

(EduSource, 1997:33)

This data indicate that only 42% of the science teachers have been formally trained in science, with over half of those having gained their science qualifications through Secondary Teacher Diploma courses. These figures constitute very low levels of subject specialisation and expertise.

Table 1.2 Qualifications of teachers in mathematics across the provinces in South Africa

Subject Qualification	Teachers qualified in mathematics	% of total mathematics teachers (n = 15 697)
Three or more years university course	1 401	9 %
Two-year university course	633	4 %
One-year university course	893	6 %
Higher Diploma of Education (science)	576	4 %
Secondary Teacher's Diploma (science)	4 284	27 %
Total Qualified	**7 787**	**50 %**

(EduSource, 1997:33)

The figures for mathematics educators are a fraction better than that of the sciences. Not surprisingly, the state of affairs regarding not enough adequately qualified teachers in the natural sciences and mathematics reflect in learner achievements across the grades, as the following discussion will point out.

Towards the end of 1996 the national and international results of the Third International

Mathematics and Science Study (TIMSS) were released. The TIMSS is the largest and most ambitious international study of mathematics and science achievement ever undertaken. The study was initiated by The International Association for the Evaluation of Educational Achievement (IEA) which is based in The Netherlands. The primary aim of the IEA is to gain a better understanding of the effects of policies and practices within and across different systems of education. Since its inception in 1959 the IEA has already undertaken 15 cross-national achievement studies (Howie, 1996:1).

The results from the South African survey will be discussed in this next section. The South African sample school group was randomly selected and was fully representative of all provinces, urban and rural communities and race groups. 5 301 grade 7 (standard 5) and 4 491 grade 8 (standard 6) learners were tested. The results of TIMSS carried out by the Human Science Research Council, placed South Africa at the ***bottom of a list of 41 countries*** in terms of learner achievement in mathematics and science by grade 7 (standard 5) and grade 8 (standard 6) learners. Singapore ranked the best in both mathematics and science, while Korea came second, followed by Japan and Hong Kong in the mathematics section. These results once again focused attention on the crisis in mathematics, science and technology education in South Africa.

It might be argued by critics that conclusions drawn from TIMSS are not strictly fair, since most of the tests were not written in the vernacular of most of the learners. Tests were written in English, and it is known that English is poorly employed at the grade 7 and 8 level at schools, especially in rural schools in the remote areas of the country. It is further said that the tests did not really test a country's school effectiveness, since the variation between test items based upon material in or outside the prescribed syllabi, showed little variation. An interesting correlation to note though, is that the highest scoring countries have a high degree of industrialisation, while lowest scoring countries all have a very large basic agricultural sector (Kahn & Volmink, 1997:4). If the TIMMS performance of the representative South African learners was so unsatisfactory, the prospects for technology education in South Africa, especially for those in the informal, remote rural and informal agricultural sections, might be even worse.

The picture regarding the problems facing science and technology education in South Africa is by no means complete without also mentioning the following aspects (Bawa, 1994:3 and Kahn & Volkmink, 1997:5):

- The fragmented, exclusive education legacy of the past, resulted in only 1/60th of African (Black) learners with the subjects, mathematics and physical science, passing their final school grade 12 examination, with exemption. For learners to pass with exemption, they need to have particular combinations of subjects, a prescribed number of these subjects have to be on the higher grade and they must achieve a minimum mark in the subjects. For learners who had to take some of their subjects on the standard grade, a minimum mark is also prescribed which is usually 10% higher than the higher grade mark. Learners who have passed with exemption, may continue with their higher education at universities. Learners who did not get exemption may continue their higher education at other tertiary institutions such as the technikons and other vocationally orientated institutions, and may enter a university at a later stage if they possess appropriate levels of prior knowledge.

- In 1990 only 8% of African students who wrote matric obtained matric exemption.

- The early differentiation (at age fourteen) in formal education where learners need to select a subject combination in either a general (social), economical or natural science field, forces a social science – natural science lopsidedness. This results in low levels of scientific-technological literacy.

- South African school curriculum development was prescribed by the needs of university degrees – therefore there was no pull towards technology components in curricula, since universities do not offer the subject "technology" as an equivalent to subjects such as anatomy or chemistry.

- The nature of teaching and learning at school level in the absence of adequate and sufficient teacher education, became heavily dependent on the "textbook-lecturing" style in many schools which resulted in rote-learning and other forms of "banking" which are not conducive to critical and creative thinking, problem-solving and innovation.

It is against this background that educational transformation and reconstruction, especially in the field of science and technology, had to be introduced. A myriad of investigations into possible reconstruction and development paths resulted in the following documents:

- National Education Policy Investigation (NEPI), 1992. The object of this investigation was to interrogate policy options in all areas of education within a value framework derived from the ideals of the broad democratic movement.

- The 1993 ANC policy conference on science and technology training (September 1993).

- White Papers on Reconstruction and Development (4 September 1994) and Education and Training (March 1995).

- The ANC's document on Implementation Plan for Education and Training (ANC, 1994:1) stated that science curricula

  ...is academic, outmoded and overloaded. Applied science and technology as well as the social and ethical aspects of science are excluded. Only 12% of higher education students pursue degree and diploma programmes in engineering and the life, physical and mathematical sciences.

- A discussion document on a Curriculum Framework for General and Further Education and Training (December 1995). The discussion document (December 1995: 1) states clearly that while providing relevant, quality basic education for all, ***"increased attention (should) be paid to areas such as mathematics, science and technology as ways of preparing the nation for the future".***

- The White Paper on in Science and Technology: Preparing for the 21st century (1996).

1.3.2.2 The history of technology education in South Africa

The roots of a technology project actually date back to the old dispensation before 1994 where initiatives were launched to introduce technology as a school subject. Prior to 1994 technology was offered as "design and technology" mainly in advantaged schools by some provincial education departments such as the ex-Natal Education Department.

Disadvantaged schools and communities depended on the service provided by non-governmental organisations (NGO's) with the names of ORTSTEP (ORT-Science and Technology Education Project) and PROTEC (Programme for Technological Careers) for exposure to some form of technology education (Kahn & Volmink, 1997:1).

In 1992, the previous National Department of Education introduced the Curriculum Model for South Africa (CUMSA) document to attempt transformation in education. Technology was included as a school subject and a core syllabus committee was set up for the new subject, technology. Objection was raised that this initiative had taken place without the inputs from the National Education Policy Initiative (NEPI) and the African National Congress (ANC) initiative. The new technology committee was chaired by the chief director of the Free State Education Department, Barend Wessels who worked on a core syllabus and guideline document for technology. The Natal Department of Education also set up a project where technology curriculum materials were being developed. As a result of pressure in the aforementioned committee, the Centre for Education Policy Development was approached.

Different views on how technology should be taken up in the curriculum persisted. CUMSA suggested that technology should be a separate subject, while the Centre for Education Policy Development advocated an integrated science-technology approach. After various discussions, Barend Wessels made a submission to the Heads of Education Department Committee (HEDCOM) regarding technology in the curriculum. HEDCOM decided in 1994 to trial the induction of technology as a school subject.

As a result, the National Project Committee (NPC), a stakeholder forum, was set up in 1995 to steer such a project. In April 1996, the NPC appointed the National Task Team (NTT) who actually became the driving force behind the project. By now the project was called "Technology 2005" or "T2005". The NTT was tasked to support, manage, co-ordinate and evaluate the process of curriculum development and implementation through Provincial Task Teams (PTT's). Their task also included the training of teachers. The timeline of this project was scheduled to last until March 1999. The NTT reported directly to HEDCOM and the Department of Education on a monthly basis (Kahn & Volmink, 1997, Reddy, 1998 and Technology 2005 Evaluation, 1998).

Running parallel to, but separate from Technology 2005, was the development of a new compulsory national curriculum for grade 1 to 9, which was to be called "Curriculum 2005". The section following will attempt to explain the relationship between Technology 2005 and Curriculum 2005.

1.3.2.3 The Technology 2005 project and Curriculum 2005

In March 1996, the Minister of Education launched Curriculum 2005. Without the submission of the Technology 2005 team, a national decision was taken that technology would be incorporated as one of the eight Learning Areas in the school curriculum. The new curriculum was to be phased in at grades 1 and 7 in 1998. Eventually it was only phased in at grade 1, which was a very wise decision considering the masses of in-service teachers who needed to be retrained for the new curriculum.

The new curriculum was more than a new curriculum – it introduced a new paradigm in education theory and practice. Curriculum 2005 is a departure from a content-based curriculum to an **outcomes-based curriculum** framework driven by a **vision of lifelong learning** for all South African learners. The outcomes-based paradigm, as well as the curriculum structures such as the National Qualifications Framework and South African Qualifications Authority, which will serve it, will be discussed expansively in Chapter 2.

The Technology 2005 project did not work out as planned, since it was taken up by Curriculum 2005. The new curriculum framework was designed around eight Learning Areas which are (Department of Education, 1997a:8):

- Language, literacy and communication
- Mathematical literacy, mathematics and mathematical sciences
- Human and social sciences
- Physical and natural sciences
- Arts and culture
- Economics and management science

- Life orientation

- Technology

In the *foundational phase* (grade 1-3) there will be only three Learning Areas, literacy, numeracy and life skills. Technology education will be incorporated into the life skills Learning Area. In the *intermediate phase* (grade 4-6) five Learning Areas will be introduced. They are language, literacy and communication; mathematical literacy, natural sciences and technology; human-social-management sciences and economics; art, culture and life orientation. Technology education will also be incorporated into the natural sciences -technology Learning Area. Only in the *senior phase* (grade 7-9) will all eight Learning Areas be implemented, where technology education will be a separate Learning Area.

For each of these Learning Areas a Learning Area Committee was set up to design frameworks and outcomes. The technology Learning Area Committee involved members from the Technology 2005 project. Finally, attempts to reconcile the agendas of Technology 2005 and Curriculum 2005, bore fruit and the Technology 2005 project was implemented in pilot schools in 1998. Evaluation, in the form of summative evaluation of this pilot project, needed to be undertaken. The Foundation for Research Development (FRD) funded the Technology 2005 National Implementation Evaluation Study. The objectives of this Evaluation Study were defined as follows (Technology 2005 Evaluation, 1999:11):

- To evaluate the implementation process of Technology 2005 (in terms of cost, feasibility, sustainability) and to establish how implementation procedures could be improved.

- To undertake a formative evaluation of selected aspects of Technology 2005 in order to provide feedback to role players such as the National Task Team, Provincial Task Teams and teachers in the sample schools.

- To establish benchmark data across a range of aspects in technology education.

- To develop a range of strategic options for policy-makers based on findings from the evaluation.

The author was a member of the Gauteng Evaluation Team and a co-writer of the final evaluation report, which was submitted on 17 December 1998 to the Centre for Science Development. All the data generated from this research are available to use in research by the author, as well as any other researchers who wish to continue this line of investigation. Where applicable, results from this research will be used to illustrate or validate certain knowledge claims made by the author. The most relevant results in terms of lessons that may be learnt from this local project will be presented in the next section.

Against this background of the development of technology education in South Africa, the discussion now turns to the role of the teacher and teacher training for technology education and specifically to problems associated with training of technology teachers.

1.3.2.4 Who will teach technology education in South Africa?

It cannot be denied that the successful implementation of any new curriculum relies heavily on the competency, commitment, dedication and sense of ownership of the teachers and principals acting as the change agents at school and classroom level. There are two aspects to this – retraining existing teachers and training new teachers who have to teach in a new system based on a new educational philosophy. The implications of a new outcomes-based curriculum, which represent a significant departure from a traditional curriculum, as well as a new Learning Area which has never officially been dealt with before in public South African schools, have far reaching consequences for pre- and in-service teacher training.

The educational innovations in South Africa imply a double mind shift to be made by future technology teachers and their educators. The first will be to conceptualise a new Learning Area with its theoretical and practice implications, as well as the outcomes-based approach from which teaching and learning have to take place. A mammoth teacher education and re-education task lies ahead.

Perhaps the same comment can be made as that by Kariyewasam (1996:223) about educational transformations in Sri-Lanka and the impact it had on preparing teachers for dealing with these transformation processes:

> *There appeared to be a lack of competent teachers to handle a programme of this nature...Their knowledge, skills and practices were so inadequate that it would have taken a quarter of a century to train them.*

This quotation is not meant to encourage pessimism, but to highlight how extensive the challenge in teacher education really is, especially training for technology education.

In the paragraphs which explored the implementation of technology education in different countries, it was often highlighted that the teacher's understanding of the nature of technology influences their teaching and assessment strategies and methodologies. The definition and nature of technology education, as it will be conceptualised and made appropriate for South African context will be explored in detail in Chapter 3.

(i) Experiences with the education of technology teachers

Many proposals and pilot programmes have been suggested for implementing technology education in various countries. The reality of proposals, as McCormick (1992:48) rightfully comments is "*what is contained in documents will only take effect when teachers share the understandings they contain. Implementing in schools is quite different from proposing".* It is the expert competent teachers who will have to make the vision, aims and outcomes of technology education reality. Various role players will have to cater for the education and training needs of the teachers in this relatively new field. In the Netherlands two streams of technology education are emerging. One is the general stream which will try to implement a new subject "technology education", while the other will continue with a "general techniques-vocational" approach. The result, De Vries (1992:38) notes, is that there is

> *... a lot of confusion among the teachers, most feel hardly competent to teach this new subject, either because they became eligible to teach it just because of their 'General Techniques' experience, or because they went through the*

extremely short and condensed retraining programme.

Barlex (1992: 24) and De Vries (1992:38) advise that *"more attention (should) be paid to conceptualization"* of technology education during in-service. It is however, the educational philosophy and understanding of the purpose and nature of a subject that will determine the practice endeavours. (Also see Section 3.5 for a detailed analysis of the nature and structure of technology and the appropriate methodology for facilitating learning in this Learning Area).

Though short and condensed programmes have their place and purpose in retraining teachers, more formalised and accredited forms of training teachers for technology education need to be considered. The State Board of Teacher Registration in Queensland, Australia for example, supports a model which was proposed for a formal four year Bachelor of Technology Education degree (Morgan & Wheeler, 1992:180-181). In South Africa, various teacher education colleges, technikons and universities are beginning to offer qualifications in the form of certificates, diplomas and degrees in technology education.

Teachers who have to teach technology in Curriculum 2005 did not obtain a formal qualification in this Learning Area. They received some form of in-service training, which varied form province to province. Although these initiatives were first attempts to retrain teachers for a new Learning Area, valuable lessons may be learnt from the local inputs.

(ii) *Lessons learnt from the Technology 2005 National Implementation Evaluation Study* (Technology 2005 Evaluation, 1998: 38-50)

The discussion to follow in this sub-section provides a situation analysis which highlights the needs in this new Learning Area. Discussions of the findings regarding the training of technology teachers, will naturally serve to sensitise the reader to the value and the possible contribution which this research can make to the generation of new knowledge in this field.

In 1998 as already mentioned, the National Research Foundation (NRF) funded a study, which had to evaluate the implementation of technology education in the pilot schools. The study was called the "Technology 2005 National Implementation Evaluation Study".

Only three of the provinces, namely Gauteng, Western Cape and KwaZulu Natal, where technology education was already offered for just under a year, were involved in the evaluation study. Part of the study was interested in the in-service training that the teachers received. In each school one or two teachers were designated to undergo the training. The teachers who were selected to attend the training were most likely those teachers who were to loose their jobs due to the fact that some subjects were to be integrated into the eight Learning Areas.

It is interesting to note that the teachers who were to teach technology used to teach or were currently teaching the following subjects (Technology 2005 Evaluation, 1998:25):

- Science (mathematics, science, biology and environmental science): 14,7 %.
- Technical subjects (needle work, wood work and technology): 10,7 %.
- Human sciences (languages, art, history and geography): 17,3%.
- Generalist (teachers teaching a variety of subjects or – in the primary schools teaching all subjects): 57,3 %.

In **Gauteng,** two teachers from each of the twenty pilot schools were trained by the non-governmental organisation called ORTSTEP. In Gauteng this form of training was a matter of project policy. Teachers attended the training on the occasional Saturday morning and during school holidays over a period of two years. The ORTSTEP training was mostly received positively and teachers reported that *"it helped a lot, and without the training I do not think that I will understand a thing"*(Technology 2005 Evaluation, 1998:38). The Technology 2005 Evaluation (1998:39) did, however find that the ORTSTEP training might not be entirely suitable for South Africa's need. One teacher did point out that it took a high-tech approach that could not be duplicated in many of the country's schools. Finally, many of the transformations relating to OBE and current curriculum issues were not covered by ORTSTEP. It must be noted however, that the ORTSTEP training started at a time when Curriculum 2005 and the outcomes-based approach were not yet official policy. Some of the feedback results from The Technology 2005 National Implementation Evaluation Study (1999:39) are the following:

- *More didactics of Technology, teaching and assessment need to be addressed during INSET.*

- *The training we have received (from ORTSTEP) in Technology will help you in a way to give Technology, but someone who did not do the training will still be able to cope in Technology.*

Another group which was responsible for the INSET in the provinces, were the Provincial Task Teams (PTT's). Each province had their own PTT. In Gauteng the PTT did not enjoy any official status from the provincial Education Department. Therefore no PTT training could be conducted during school times and had to take place in the teachers' own time and purely at the discretion of the teacher. Consequently attendance was sporadic. Teachers who attended the ORTSTEP training also had to attend the PTT training, where they were suppose to assist the PTT with the training where necessary. The comments below are made by teachers who attended both the ORTSTEP and PTT courses (Technology 2005 Evaluation, 1999:48):

> *The (PTT) training adds to my knowledge. Some of the things are a repeat of ORTSTEP, but for me I do not feel it is a repeat of the work, because if I go there I can listen again, because I did not have full training in that subject; we only had one day a week at ORTSTEP.*

A teacher who attended both ORTSTEP and PTT training compared the different methodologies which were used during their training and comments as follows (Technology 2005 Evaluation, 1999:48):

> *At ORTSTEP we were trained the OBE way and in the technological process. But at (the PTT) training we were taught a different way, which is fixed and not OBE.*

Teachers who only attended PTT training courses and no ORTSTEP training, made mixed comments (Technology 2005 Evaluation, 1999:49):

- *What I gained from the workshop is that they explain to us all the things we are going to work with. I was able to come up with some* *ideas of what to do in the class.*

- *No value at all! I need training to be able to work with more confidence. There is not enough time in a semester to be trained.*

Where a PTT conducted training sessions with the personnel of a whole school, teachers not directly involved in technology had a greater understanding of the integrative nature of technology and were more supportive of implementing technology. In school-based trained schools teachers from other Learning Areas collaborated with the new technology teachers to accommodate learning tasks which involved technological issues.

In **KwaZulu Natal** it appears that the PTT was very successful with their INSET work. Training consisted of six weeks during the year from May through December. Training consisted of intensive weekly sessions (Monday morning until Friday afternoon), after which teachers were asked for feedback and suggestions. Each school had to send at least one teacher, although some schools opted to send two. Apart from the training, teachers had regular back-up and support from the PTT who visited schools at least once a term between the training sessions. Good training materials also added value to the process. Comments regarding the training provided by the PTT were uniformly positive (Technology 2005 Evaluation, 1999:51):

- *Very valuable and I think it was a wonderful course. It opens up a whole new world of learning, and the Technology 2005 Task Team had really motivated us and explained all the jargon. They are doing it very well. This is my first experience with the subject.*

- *Very valuable, it makes you aware of the situation around you. I have more knowledge now and know that Technology is the centre of all Learning Areas.*

In **Western Cape**, INSET consisted of one week training before the start of the school year. Pilot schools were invited to send two teachers each. Follow-up workshops were delayed until mid-October due to administrative inefficiencies within the provincial Education Department. The PTT visited schools several times during the year to offer assistance to teachers. The value of the training elicited mixed results (Technology 2005

Evaluation, 1999:52):

- *Training was only a few days, It was a depressing week – teachers were treated as students. They spent four days on two projects, and my initial excitement about the project was dampened after that training.*

- *The Wellington thing was the best I have been to. I think that the main reason for that was that it was hands-on; we actually did the same things as children of the age.*

- *Well, as for training, I think we need a little more. The once-off week in the year isn't sufficient, you know.*

After the core group of teachers have been trained, each of the three provinces decided on a "cascading" or peer training model for the in-service training of their teachers. This model was said to have the potential for providing teachers with in-school back-up and support. The core group of teachers had to go back to their schools to train other teachers who were to teach technology (Technology 2005 Evaluation, 1998:6). Results finally showed that the cascading training model did not fully realise due to the following reasons (Technology 2005 Evaluation, 1998:6):

- The core group of teachers did not have time to train other teachers who also did not have time due to the fact that they had to teach other subjects as well.

- The core technology teacher could not use time in school or after school, because all the teachers were involved with sport and other extra mural activities. They did try however, to use the occasional off period for training during exam time.

- Not all the province's technology task teams gave substantial back-up and school support to enhance the sustainability of this new Learning Area.

For South Africa it can be concluded that technology education is included in Curriculum 2005 and it will have to be taught and learnt in an outcomes-based paradigm. This has the implication and imperative that teachers have to be trained accordingly.

1.4 Problem formulation and research questions

Teachers in South Africa are in the midst of all the educational transformation. Technology educators in particular have to implement a new Learning Area within the new Curriculum 2005 from an outcomes-based framework. With this new Learning Area, arrived the need for trained technology educators. Various in-service training programmes have been introduced with different degrees of success in the provinces. Overall, the in-service training that has been provided for retraining teachers, especially technology teachers has been inadequate. Furthermore, there are no definite signs that provincial education departments intend to put more effort and resources into in-service training, for various reasons. Therefore, the only long term hope of having adequately trained technology teachers lies in pre-service training.

The need is clear that a suitable model or approach of training technology teachers needs to be found, so that their competency may result in their learners maximising their potential in this field. Without the expert competent teacher, the vision and futuristic aims of technology education will not become reality.

The following problem formulation can serve as a general statement containing the conceptual underpinnings and focus of this research.

How should teachers be trained to become effective facilitators of learning in an outcomes-based technology curriculum?

The broad problem formulation will be broken down into research questions, which will provide foci for the research. The specific questions which will be addressed in this research, are the following:

1 What is the nature, extent and vision of educational transformation in South Africa?

2 What is the conceptual framework and implications of the outcomes-based

education paradigm for the professional training and development of teachers?

3 What is the substantive and syntactical structure of technology education?

These three questions are fundamental background issues that will be explored through the literature review.

The following questions will be researched through means of quantitative and qualitative research methods.

4 Is a problem-based learning model (PBL) a suitable, effective model to use in the training of pre-service technology teachers who have to facilitate learning within an OBE framework?

5 Will pre-service technology teachers be able to transfer their competencies obtained through a PBL training model to authentic classrooms to facilitate learning through PBL?

6 How will the PBL strategy used by the pre-service technology teachers impact on the learning quality and attitudes of learners?

1.5 Research methodology and design

The research methodology used for this research is not based on a single type of methodology. The different needs in this research are addressed through using different methodologies to answer the six research questions.

Creswell (1994: 177-178) describes a mixed methodology design where aspects of the quantitative and qualitative paradigms can be combined in the introduction, literature review, theory use, purpose statement and research questions. This approach adds complexity to a research design, but the main attraction of this design is that it uses the advantages of both the qualitative and quantitative paradigms. Obtaining data from a variety of resources through both quantitative and qualitative methods, will enhance the quality of knowledge claims made in this research. According to Leedy (1993:139) the decision on which methodology to use, depends on *"the nature of the data and the* *problem for research".* The nature of the research conducted in practice, following the literature research, manifests in two broad categories, namely quantitative and qualitative research.

To explain how these two methodologies were combined in this research, the information is presented in table format. The table describes the different resources which served as data points, the instrumentation used to gather the data, as well as a description of the **particular methodology** used to gather and analyse the data.

Resources: Data points	Data gathering instruments	Type of methodology applied
1 Grade 10 learners	1 Pre- and post- knowledge test written by the experimental and control group.	The data from the pre- and post-knowledge test, the attitude questionnaire and the LEMOSS questionnaire were quantitatively analysed by means of empirical-statistical methods.
• Experimental group • Control group	2 An attitude questionnaire completed only by the experimental group.	The comments by learners from the experimental group were **qualitatively** interpreted to enrich the empirical findings obtained from the attitude questionnaire.
	3 The learning and motivation strategies in science questionnaire (LEMOSS) completed by experimental group learners.	
	4 Brief written comments by learners from the experimental group to determine reasons for their attitude.	
2 Pre-service final year students	1 Written reports on their perceptions of technology and technology education prior to the PBL training. 2 Semi-structured individual interviews. 3 Log-books kept individually by each pre-service teacher of their practice implementation.	These instruments were **qualitatively** administered. 1 The written reports were analysed. 2 The interviews were transcribed and analysed. 3 Written texts in the log-books were analysed.

The details of the resources and instruments presented in the table will be elaborated in Chapter 4. The purpose of this table is merely to give an overview of how the quantitative and qualitative methodologies were combined in this research design.

1.6 Significance of this research

The previous parts of this chapter have already highlighted some of the shortcomings which might be addressed through research of this kind. Firstly, the entire field of education and training in South Africa is in various stages of reform, based on the paradigm of outcomes-based education. This is a radical departure from content-based curricula and the transmission model of teaching and learning. To retrain teachers to understand the philosophy, practice and systems of a new approach to education is a challenging endeavour which needs to be engaged in. Secondly, attempts have been launched to prepare in-service teachers for a double duty: one for practising a new outcomes-based approach and the other for implementing a new Learning Area, technology education. The in-service efforts were noble, but did not have the impact and sustainable results ideally envisaged. As a long-term solution, this research accepted the challenge of trying to find answers and to test findings on how to train pre-service teachers for their new and important task.

After an extensive literature research, a meta-curriculum model was designed which was used as the basis of a pre-service training programme for science teachers who were trained to facilitate technology as well. This model explores a problem-based learning approach for two reasons. Firstly, because problem-based learning is an overarching strategy which has potential to operationalise outcomes-based practice. Secondly, the problem-based learning strategy is coherent with the innate nature and structure of technology education. The model was therefore named the OBE-PBL model. This model served as the pre-service training model. The model was implemented in the same way that pre-service technology teachers are expected to teach in authentic school contexts once they have left the university classrooms. The "what" and "how to" of their course was **modelled** to the pre-service teachers. In other words, the training programme did not use a transmission-lecturing approach to develop their technology education and professional competencies. This particular section of the research may contribute towards the search for effective teaching and learning strategies which may be used within the OBE framework, and in particular in technology education. In both of the new initiatives and especially in relation to one another, knowledge and guidelines for practice in terms of curriculum, classroom implementation and assessment, are needed. This research hopes to fulfil some of the needs of the practising cadre of teachers who have to "make it happen" at classroom level.

A significant contribution of this research is the fact that it went beyond the design and implementation of the OBE-PBL model for pre-service teachers only. This research made a **direct link** between the pre-service training and the classroom practice. Often when trainees exchange classrooms for their real world work place, they cannot transfer and sustain their newly gained competencies. If any pre- or in-service teacher cannot successfully transfer their competencies to real classrooms and act as change agents in their schools, then the training was a sterile, expensive and worthless exercise. The PBL strategy is investigated as the key factor contributing to bridging the gap between knowledge acquisition and application when and where it matters. The fact that pre-service teacher training success is tested in real classrooms, contributes to complexity, but also to the uniqueness of this research. Feedback from both the pre-service teacher level and the learner classroom level, is used to refine the OBE-PBL model and the implementation thereof for future training inputs which might help the pre-service teachers to make an effective transition from university to workplace.

In summary, this research will contribute towards both theory in terms of scientific knowledge and especially the practice of training pre-service teachers to facilitate technology education from an outcomes-based paradigm and to do that effectively and successfully in their real work place, the school.

1.7 Overview of the study

The first chapter orientates the reader by identifying and formulating the **problem** to be addressed by this research. The rationale and brief history of technology education internationally as well as nationally are presented. It is against this background that the problem is explored in depth and this makes it possible to formulate research questions to be answered.

The introduction of technology education in South African curricula, is one of the many educational transformation initiatives. To comprehend the implications of technology education in curricula, it is of vital importance to have a holistic view of the education transformation process, and transformation in South Africa in general. Since the transformation intended in education is more than cosmetic transformation, the underlying paradigm and vision will be explored in chapter two. The implications and imperatives of **outcomes-based education** on curriculum structures, curriculum design, educational theory and practice are contextualised.

The third chapter presents a conceptual framework of what technology education is and what it is not. Once the terrain of **technology education** is clarified, the nature and structure of this new Learning Area will be highlighted, since it has far reaching implications for the training of teachers who are to facilitate technology education. Another purpose of this chapter is to explore the possibilities of a problem-based learning model (PBL) as an appropriate model for pre-service technology teacher training from an outcomes-based perspective. The foundations addressed in chapters two and three will culminate in the design of a meta-model, called the OBE-PBL model, which will be implemented and evaluated on two levels. Level one will entail the training for the pre-service technology educators based on the OBE-PBL model and, on the next level, the pre-service teachers will implement the model in authentic classroom contexts.

The **research design** and **methodologies** are discussed expansively in chapter four. The six month problem-based training programme that was used to build the capacity of the pre-service teachers to become facilitators of technology education, is discussed. Training in isolation without giving the pre-service teachers the opportunity to implement their competencies in real life practical situation, is sterile and abstract. Therefore, a report is also given of their one month experience in the classrooms as facilitators of technology education. The interventions with both the experimental and control groups are also discussed in this chapter.

In chapter five, the OBE-PBL model used for the training of technology teachers is investigated by quantitative and qualitative methods. Data will be gathered from two data sources, namely the pre-service teachers themselves and the learners with whom they have intervened. The results obtained from different resources are presented, analysed, interpreted, and conclusions are drawn with the different research questions to be answered in mind.

The final chapter, chapter six, reflects holistically on the research and the research questions asked. Conclusions are drawn about the effectiveness of the OBE-PBL training model and recommendations are made for future research.

CHAPTER 2

A REVIEW OF THE LITERATURE ON CURRICULUM DEVELOPMENT AND REFORM, WITH PARTICULAR REFERENCE TO SOUTH AFRICA

2.1 Introduction

Chapter 1 provided a rationale for the proposed research which is underpinned by national curriculum reform in South African education. Transforming a curriculum has implications for every dimension and role-player dealing with curriculum. Any attempt at changing curriculum practice in South African schools must be evaluated from the perspective of what the government is trying to achieve through its curriculum reforms. In turn, these curriculum reforms must be interpreted and critically evaluated from the broader perspective of curriculum theory. This chapter places the present research into context by first providing a working definition for curriculum as well as a brief overview of the major philosophical approaches to curriculum. This overview will highlight the reality of change and the issues driving change, which is not unique to South Africa, since it has been happening over decades.

The transformational outcomes-based education paradigm, which is embraced as the guiding paradigm for educational reform in South Africa, will be viewed from three different perspectives. The first two perspectives will be discussed in this chapter, while the third will be addressed in Chapter 3. The first perspective is a discussion of outcomes-based education as a *philosophy of education*, and the second as a curriculum framework and *system* that has been created as the vehicle for restructuring education in South Africa. The system referred to entails the National Qualifications Framework (NQF), Curriculum 2005 and other supporting structures like the National Standards Bodies (NSBs), The third perspective, which will explore some implications of *OBE in practice*, for *technology education* in particular, will be addressed in the Chapter 3.

2.2 Defining curriculum: Key dimensions and concepts

Up until now in this research, curriculum has been referred to as a general concept inextricably linked with education. It would be appropriate at this stage to clarify exactly what is meant by the term curriculum before continuing with any discussions on curriculum.

The concept of curriculum is elusive and epistemologically ill defined, because of the fact that education is everybody's business, from the lay person to educational scientists. Another factor contributing towards the problem of precise terminology is that there is not much agreement on where curriculum matters finish and where the rest of education begins. According to Pratt (1994:5) the acts of instruction, teaching and learning are not curriculum, for curriculum refers to plans or blueprints for instruction — but there are alternative interpretations of the concept.

By 1971, Rule (Lewy, 1991:26) had already identified 119 different definitions for curriculum which may be delineated against two extremes: specific and prescriptive versus broad and general (Ornstein & Hunkins, 1998:10). A linear, more prescriptive definition is that of Tom (1984:89), which is also in line with Tyler's (1958) and Taba's (1962) description, who define curriculum as a plan for teaching or instruction, while Pratt (1994:5) expanded the definition to "*a plan for a sustained process of teaching and learning*". A broader definition of curriculum is rooted in Dewey's (1938, 1975) explanation of the relationship between education and learner experiences. Shepherd & Ragan (Ornstein & Hunkins, 1998:9) assert that a curriculum *"consists of the ongoing experiences of children under the guidance of the school...(where) children achieve self-realization through active participation within the school"*. The tendency to define curriculum in terms of experience, and not merely a plan, arose as a result of the feeling that what was planned in a written document, was not necessarily put into practice by means of experiences (Lewy, 1991:27).

Closer to home, Jansen (1984) also added his voice to the plethora of definitions. According to him "*a curriculum is a plan or a programme for teaching and learning prepared in the light of certain goals and which contains at least a reference to selected* *and sequenced learning content*" (1984:90).

Within the context of this study, the working definition will include both the definitions as formulated by Van Rooy (1996) and the National Education Policy Investigation (NEPI, 1992). According to Van Rooy (1996:92) curriculum is defined as follows:

> *The curriculum is the interrelated totality of aims, learning content, evaluation procedures and teaching-learning activities and opportunities and experiences which guide and implement the didactic activities in a planned and justified manner.*

According to the National Education Policy Investigation (NEPI, 1992:1-2) curriculum refers to "*the teaching and learning activities and experiences which are provided by schools*". This definition includes the following components:

- The aims and objectives of the education system as well as the specific goals of the school.
- The selection of content to be taught, how it is arranged into subjects, programmes and syllabuses, skills and processes.
- Strategies for teaching and learning, as well as relationships between teachers and learners.
- The forms of assessment and evaluation which are used.

This definition of curriculum by NEPI brings together a number of different interests involved and necessary for effective and successful education. The interests are:

- The learning and development of individual learners.
- The nature of knowledge and developments in knowledge itself.
- The labour process of teachers, and their values and interests.

- The changing needs and interests of the broader society.

- The values, entitlements and requirements of citizenship in a particular society.

- The human resources needs of the economy (NEPI, 1992:2).

The only shortcoming in these definitions in terms of their suitability for the present South African education situation, is the absence of the concept "outcomes". Both of these definitions were formulated before the outcomes-based approach was national policy. Since outcomes are the point of departure in the curriculum design process, this concept should be included in the first sections of both of the definitions to stand alongside the terms aims and goals.

The next section will provide a backdrop in terms of educational philosophies which have guided curriculum development and change processes in this field.

2.3 Philosophical foundations of curriculum

The curriculum is central in the educational process and therefore the mission envisaged for education should be mirrored in curriculum endeavour. Many dimensions and directions of curriculum discourse have been described over the ages which differed paradigmatically from one another. Curriculum philosophies and actions were vested in the world view of a specific time slot in the course of history. Lovat & Smith (1995:11) agree that there is an underlying social, political and economical philosophy for each historical period which impacts on education and curriculum. As empires and governments rose and fell, so did curricula with their guiding paradigms rise and fall. The reason why education and consequently curricula are delicate terrain for covert power battles is best demonstrated by Bernstein's (1971: 47) much quoted statement:

> *How a society selects, classifies, distributes, transmits and evaluates the educational knowledge it considers to be public, reflects both the distribution of power and the principle of social control.*

The quotation's reference to "distribution of power" activates age old, controversial issues which have tormented educationists and curriculum planners through the decades. The NEPI Report (1992:2) also acknowledges the fact of a complex set of dynamic relationships associated with curriculum decisions when it states the following:

There are, therefore, important social and political dimensions to the curriculum. The way in which knowledge is organized in the school curriculum is a social activity which produces a social product. It is drawn up by particular groups of people; it reflects particular points of views and values; it is anchored in the experiences of particular social groups; and it produces particular patterns of success and failure. Viewed in this way, the curriculum can never be neutral or removed from patterns of power.

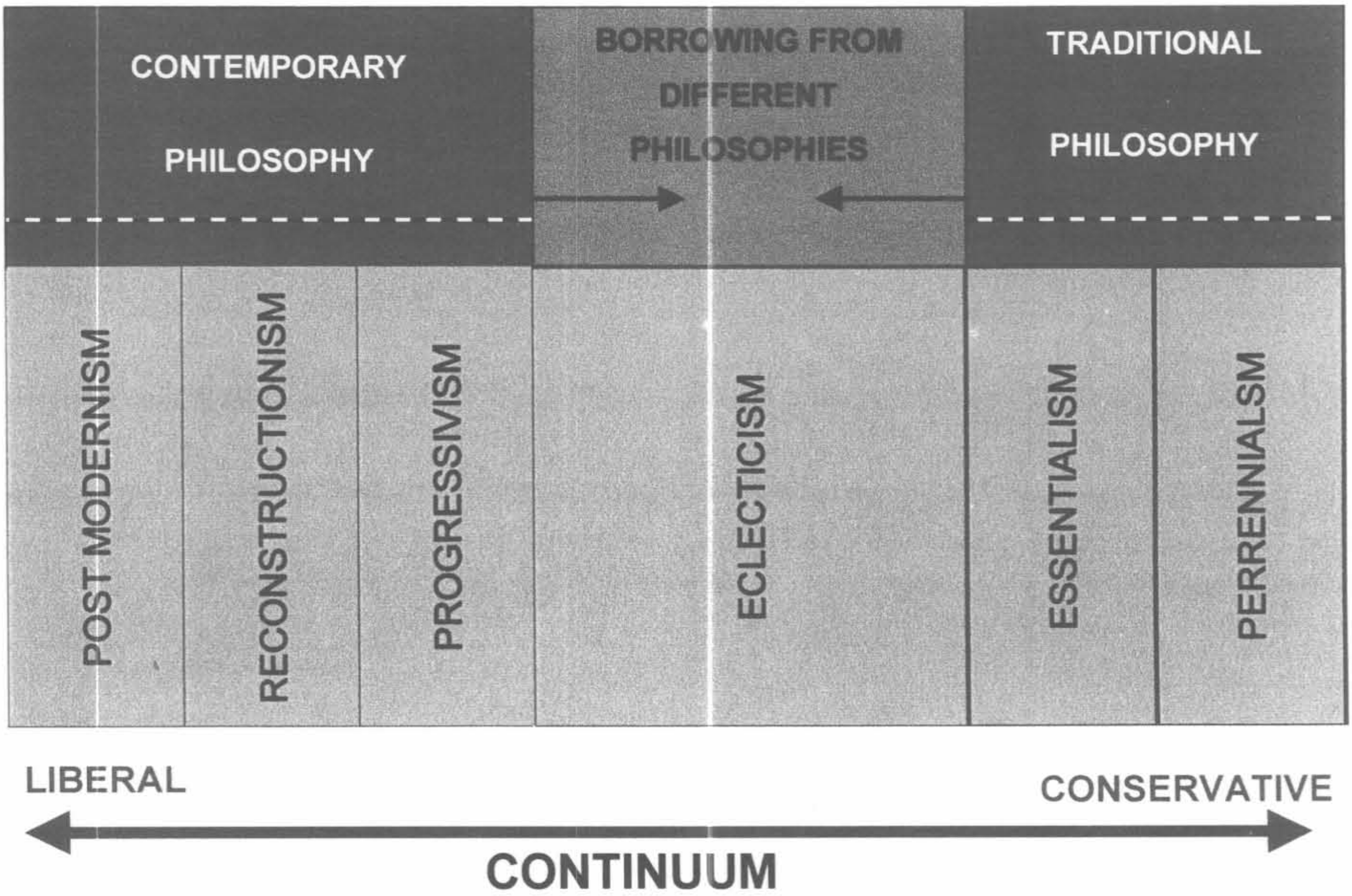
The points made here are particularly relevant in the context of South Africa's current educational reforms which have a stated intention of changing patterns of power, patterns of success and failure and (some would say) the basic nature of South African society.

As a point of departure to introduce the vast field of curriculum, as well as patterns of transformation in this field, different **philosophical viewpoints** underpinning curriculum inquiry will be discussed. Major philosophical viewpoints in the field of education and consequently in curriculum have given meaning and have directed missions, decisions and actions in the field of education. Hopkins (Ornstein & Hunkins, 1993:35) stressed the importance and role of philosophy in curriculum, especially when being confronted with prominent change imperatives in education, when he expressed the following:

Philosophy has entered into every important decision that has ever been made about curriculum and teaching in the past and will continue to be the basis of every important decision in the future. There is rarely a moment in a school day when a teacher is not confronted with occasions where philosophy is a vital part of action. An inventory of situations where philosophy was not used in curriculum and teaching, would lead to a pile of chaff thrown out of educative experiences.

If the different philosophies which have influenced and are still influencing curriculum thinking are considered, different classification schemes are possible. For the purpose of providing an overview in this research, a classification scheme will be used where the major philosophies of education will be depicted along a continuum varying from the traditional to contemporary. At the far left are the liberal philosophies, reconstructionism and post-modernism, and at the far right the conservative such as perennialism, with progressivism and essentialism in between (Ornstein & Hunkins, 1993:61, Oliva, 1992:193 and Slattery, 1995:67-102). Figure 2. 1 represents this continuum.

Figure 2.1: Educational philosophies underpinning curricula



The following brief summaries of these philosophies highlight the major influence they had on curriculum. This background provides a position from which to interpret the recent curriculum reforms in South Africa.

2.3.1 Perennialism

Perennialism is the oldest of the educational philosophies. It is rooted in realism where the aims of education are seen as disciplining of the mind and the development of the ability to reason. Therefore, true to the tradition of Plato and Aristotle, perennialist thinking focuses on that domain of the past which encompass universal, generally agreed upon knowledge. A highly academic curriculum consisting of the Quadrivium and Trivium was advocated with emphasis on the three R's, moral and theological studies and subjects such as geometry, Latin, Greek, grammar, rhetoric and logic (Oliva, 1992:195–196; Ornstein & Hunkins, 1993:40– 42 and Pratt, 1994:9). Hutchins (1963:18) who was a great spokesperson for perennialism stated the function of education to be the following:

> *The ideal education is not an ad hoc education, not an education directed to immediate needs; it is not a specialized education, or a pre-professional education; it is not a utilitarian education. It is an education calculated to develop the mind.*

To fulfil the function of education referred to in the quotation, the curriculum is **subject-centred** where the teacher is viewed as the authority and expert in the subject field. The dominating teaching methods entail lecturing, oral exposition and rhetoric (Ornstein & Hunkins, 1993:42).

2.3.2 Essentialism

From the 1930's to the year of Sputnik in 1957, essentiaslism emerged as the prominent and popular educational philosophy informing curriculum endeavour. This philosophy resulted in the curriculum being organised around cognitive and intellectual essentials which, therefore, explains the emphasis on the three R'S and other core academic subjects such as English, mathematics, science, history and a foreign language. Minor or "soft" subjects like art, physical education and music appreciation were considered as expensive fads taking up too much of the available educational resources (Ornstein & Hunkins, 1993:45).

Essentialism differs from perennialism in that although it also values essential subject matter, it is not rooted in the past only, but focuses more on contemporary issues while aiming to preserve the cultural heritage (Oliva, 1992:196). Essentialists find themselves in harmony with **behaviouristic principles** where the learner is cast into a passive role of receiving and responding to stimuli from the teacher (Cagné, 1985). The stimulus-response relation encouraged didactical practices such as programmed instruction, drill, standardised tests, behavioural objectives and teaching machines which were popularised by Skinner (Oliva, 1992:197-198).

Although present day essentialists are more moderate than they were during the Sputnik years in that they provide to an extent for an individual's abilities and interests, a learner-centred approach is still strongly criticised. The reason being that "*the school is ... side tracked, from its original mission when it de-emphasises cognitive needs, and attends to the social and psychological problems of students*" (Ornstein & Hunkins, 1998:42).

2.3.3 Progressivism

In the early twentieth century, progressivism developed from pragmatism. This development was led by John Dewey with publications such as *Democracy and Education (1916)* and *My Pedagogic Creed (1929)* and maintained that it was time to subordinate subject content to the learner (Kanpol, 1995:368-369 and Oliva, 1992:198-199). Because of the pluralistic, changing nature of reality, Dewey did not see much need for focusing on a static body of knowledge like the perennialists and essentialists did. According to progressivist thought, the emphasis of learning was on **how** to think and not **what** to think (subject content). Therefore, learning strategies which could enhance effective learning were important and included problem-solving competencies and scientific inquiry (Ornstein & Hunkins, 1993:50 and Pratt, 1992:15).

Dewey (1902:7-14) explains the difference between the essentialist and possitivist curriculum as follows:

> *One school fixes its attention upon the importance of the subject matter of the curriculum as compared with the contents of the child's own experiences ... Subject matter furnishes the end, and it determines method. The child is simply the immature being who is to be matured; he is the superficial being who is to be deepened. ... It is his to receive, to accept.*
>
> *Not so, says the other sect. The child is the starting-point, the center, and the end. Personality, character, is more than subject matter. Not knowledge or information, but self-realization, is the goal.*

Dewey did, however, state that just as he condemned old philosophies emphasising knowledge for its own sake, he attacks those who believe that knowledge had no or little value (Ornstein & Hunkins, 1988:50). Where the perennialist regards truth to be absolute and based in the past, the essentialist views truth as cultural heritage while the progressive pragmatist regards truth as relative, changing and incomplete (Oliva, 1992:200). Thus methods and tools for searching the truth become important – hence the reference to scientific method.

Scientific method: The progressivists viewed the scientific method as a means of fostering problem-solving competencies and reflective thinking which could be implemented in any area of human life. The scientific method, therefore, was both a means and an end. The consecutive processes which constitute the scientific method are: (a) identify a problem (b) form a hypothesis (c) collect data and information (d) analyse data and information (e) draw conclusions and deduce implications and (e) accept or reject the hypothesis (Evans, 1970:9).

Although the scientific method is a generally accepted method in problem-solving, it must be realised that it has it limitations as well in searching for new knowledge. Taba (1962:184) legitimately warned against using the scientific method as the only method to teach thinking and problem-solving when she stated:

> *Subsuming all reflective thinking under the category of problem solving has also caused certain elements of thinking to be neglected, especially those which, although involved in problem solving, are not fully attended to while solving problems. Among these are such mental processes as concept formation, abstracting, and various methods of induction.*

A summary of progressivist curriculum thinking is not complete without referring to both the relevant and humanistic curriculum.

The relevant curriculum:

During the 1960s curriculum development adopted a learner-centred approach as opposed to a subject-centred approach. It was argued that learners would take more responsibility, be more interested and actively involved in learning if classroom experiences were to be built on real-life experiences (Black & Atkin 1996:35-36 and Doll, 1986: 24-25).

From the call for relevance emanated the following needs:

(a) Revised and new courses incorporating learner interests and problems.

(b) Educational alternatives, electives, mini courses and open classrooms.

(c) Relaxation of academic standards and admission standards.

(d) Individualisation of instruction by means of independent study and special projects.

(e) Extending the curriculum beyond the four walls of the classroom by means of work-study programmes, credit for life experiences and off-campus courses.

The initial intention to recognise learners' needs was a good one but, as Oliva (1992:205) summarises *"there can be no doubt that some of the progressivist schools went to extremes to accommodate the needs and interests of children"*. Hence, the curriculum appeared disorganised and difficult to evaluate in comparison with the tidiness of the essentialist curriculum.

The humanistic curriculum:

As a reaction to what was viewed as an overemphasis on subject matter and cognitive learning, advocates for this view promoted the idea of humanising schools. This curriculum gained impetus with the growth of child psychology which deals with issues such as valuing, freedom to learn and personal fulfilment (Combs, 1982 and Ornstein & Hunkins, 1998). Advocates of the humanistic approach, such as Maslow (1962) and Rodgers (1983), contend that by attempting to be rational-scientific, schools miss the personal and social aspects of instruction, also ignoring the artistic, physical and cultural aspects of subject-matter (Ornstein & Hunkins, 1998:47). Affective outcomes along with cognitive outcomes are promoted by the humanistic curriculum.

Curriculum activities and teaching methods which are associated with this curriculum approach, include the following:

- Lessons based on real life experiences.
- Field trips and group projects.
- Artistic endeavours and dramatisation.
- Homework and tutoring centres.
- Co-operative, independent and small group learning as opposed to large group, competitive teacher-dominated learning (Ornstein & Hunkins, 1993:7-8).

Critics of the humanistic curriculum suggest that the drawback is its lack of attention to educational excellence and academic productivity (Oliva, 1992:206, Ornstein & Hunkins, 1993:8 and Pratt, 1994:17).

2.3.4 Reconstructionism

Branching out from John Dewey's philosophy (1902) which interpreted the function of education from both psychological and social view points, reconstructionism seeks not to simply transmit cultural heritage, or to study social issues, but to involve **schools as change agents** in solving political and social problems (Oliva, 1992:194 and Pratt, 1994:11). Pinar (1988:v) describes the alternative, reconstructed view of the curriculum field as follows:

> *The field of curriculum has undergone an enormous change – a reconceptualization if you will – during the past twenty years. From a field concerned with the development and management of curriculum it has evolved into a field more concerned with scholarly understanding of several dimensions of curriculum. These dimensions include issues of development and management; however, these are explored through political, gendered, phenomenological, and other means.*

Pinar (1988:xii-xiii) continues to explain the interests and main focus of reconceptualist theorists as follows:

> *The reconceptualists tend to concern themselves with the internal and external experiences of the public world. They tend to study not "change in behavior" or "decision making in the classroom", but matters of temporality, transcendence, consciousness, and politics.*

Reconstructionists are of the opinion that this philosophy is appropriate for a society in crisis. According to reconstructionist thinking, teachers are the vanguards for a better, new social order (Ornstein & Hunkins, 1998:55, Oliva, 1992:193 and Pratt, 1994:11-16). As for the curriculum, reconstructionists place emphasis on content that represents controversial national and world problems and social issues such as unemployment, poverty, housing, and health needs, as an attempt to solve these global concerns (Oliva, 1992:194).

2.3.5 Post-modernism

The post-modernists contend that curriculum cannot be pinned down to one entity and context, because they abandon the ideas of unity, certainty and predictability. They see the world and therefore curriculum to be emergent, fluid, chaotic, open and pluralistic. Post-modernism acknowledges the construction or birth of new meanings from the chaotic deconstructed pool of knowledge (Constas, 1998 and McLaren & Hammer, 1989). According to Slattery (1995) modernists fragmented knowledge into discrete and separable building blocks of information and thus destroyed meaning. The danger of fragmentation, Bohm (1990:1-2) warns is the following:

> *Fragmentation is now very widespread, not only throughout society, but also in each individual and this is leading to a kind of general confusion of the mind, which creates an endless series of problems and interferes with our clarity of perception so seriously as to prevent us from being able to solve most of them.*

> *Thus art, science, technology and human work in general, are divided up into specialities, each considered to be separate in essence from the others.*

> *Becoming dissatisfied with this state of affairs, men have set up further interdisciplinary subjects, which were intended to unite these specialities, but these new subjects have ultimately served mainly to add further separate fragments....*

Post-modern thinking tries to restore meaning and the demolition of *"Pink Floyd's wall that separates bricks of truth and virtue, values and facts, curriculum and social justice"* (Steinberg & Kincheloe, 1995:xi). Post-modernists are concerned with **affectiveness, problems, emotions** and **uncertainty**, while modernists are concerned with **effectiveness, rationality** and **measurable certainty.** Theorists like Burbules & Rice (1991), Giroux (1992,1993,1994), Kanpol & McLaren (1995), Kincheloe & Steinberg (1993), Peters (1995) and Slattery (1995) have portrayed the problematic issues regarding multi-realities and diversity in the post-modern era of education. Kanpol (1995:360) argues that "*school clientele (students and teachers) can no longer rely on singular truth or one reality for knowledge*". Oliver & Gershman (1989:7) stretch this argument on post-modern multiple realities as opposed to traditional realities even further where they explicate that:

> *We are at the end of an age, so that its metaphors and symbols no longer explain where we have been nor inform us about what next to do.*

In a post-modernist curriculum the following characteristics are revealed which have a practical impact on curriculum development and implementation (Spector, 1993:9-19 and Hellemans, 1989:100):

- A reduced amount of content loaded with detail. A basis for general formative education is focused on the mastering of general competencies and fundamental relationships in life.

- The rigidity of traditional subject content is repealed in favour of the immediate supple integration of any new knowledge and/or processes in the curriculum to make it immediately relevant.

- Traditional disciplinary boundaries will be blurred in favour of integration, co-ordination and inter-relatedness of concepts. The emphasis is on holistic concepts and conceptual frameworks.

- Science will be portrayed as a dynamic field challenging established truths. Scientific activity is regarded as a human activity which is responsive to human and societal perceptions and needs. Science is no longer viewed as mechanistic, impersonal and ultimately objective.

- Because of the integrated and inter-related nature of reality, content will rather be organised around themes and problems, than around the structure of a single discipline.

- The curriculum will be sensitive to the values of multiple cultures, races, males and females and will allow for different learning styles.

- The curriculum will devise co-operative and collaborative learning experiences which will discourage a teacher-centred and teacher-dependent attitude. It implies a break away from a textbook and lecturing approach to an activity-based, hands and minds on approach.

- The curriculum will focus on open-ended inquiry and communication, rather than drill and practice.

These characteristics also show a very strong resemblance to the characteristics of transformational outcomes-based education, which will be discussed in detail in Section 2.4.1 and 3.2.

This overall discussion has shown that curriculum can be viewed from various perspectives and that curriculum foundations are not static, nor separate and isolated. The following comment made by Slattery (1995:152) summarises the fundamental ideas of post-modern curricula:

Curriculum .... in the postmodern era emphasizes discourses that promote understanding of the cultural, historical, political, ecological, aesthetic, theological, and autobiographical impact of the curriculum in the human conditions, social structures, and ecosphere rather than the planning, design, *implementation, and evaluation of context-free and value-neutral schooling events and trivial information.*

2.3.6 An eclectic approach to educational philosophy

The principle of an eclectic approach to educational philosophy, ties in closely with the discussion on post-modernism in the previous section. As indicated in Figure 2.1, eclecticism refers to the idea of borrowing of beliefs from one or more of the existing philosophies depending on the context and aim of a particular philosophy. Kanpol (1995:359-360) confirms the fact that no single educational philosophy may be considered static and complete when dealing with education.

The short overview of educational philosophies influencing curricula, attempted to show that change is not a characteristic of the current times only - it has been happening through the ages. It is also not unique to the South African context. This background discussion must be kept in mind when the changes taking place in South African education are discussed in the second part of this chapter. It only serves as an informative background against which to orientate, interpret, analyse and scrutinise innovations evolving in the educational field of curriculum inquiry in the modern day and age, also in South Africa.

2.4 A new paradigm for the restructuring of education in South Africa

This section will explore the philosophical paradigm which has immediate and far reaching implications for curricula in the education and training sectors of this country.

2.4.1 Introduction of the new paradigm evolving in South African education and training

Although not an official member of the Organisation for Economic Co-operation and Development (OECD), South Africa faces the same concerns regarding the state of education and training as all the OECD member countries about which the following was stated in a joint curriculum reform report (Black & Atkin, 1996:ix):

> *[They are concerned about the] relative failure of their respective workforces to cope with changing economic realities and to compete on world markets. This concern has led to a re-examination of the aims and objectives of education, and, subsequently, to reform of curriculum and assessment.*

This, according to Lovat & Smith (1995:10-11), is probably no accident because at times of economic crisis or downturn such as the late 1890s, 1930s, 1980s, and currently, discussions about curriculum tend to "*focus on questions of specifying clear objectives in outcome terms that can be tested by nationally established performance indicators*". They continue their argument by saying that when the economy is strong, jobs plentiful and people are well off in terms of material goods, there is little concern over education and what schools are doing. However, when economic conditions worsen, concerns are raised about a country's ability to compete on world markets and their young people being unemployed.

South African decision makers, practitioners, managers and other stakeholders have taken the view that in order to achieve significant levels of economic growth and to become internationally competitive, the quality of education and training had to be drastically improved before it could meet the country's needs. The National Department of Education (1997e:10) argues that the South African economy

> *serves here as a good example where changes in the relative contribution of the various economic sectors have serious implications for a future curriculum. For instance a decrease in the primary sectors from 45% during the 1910 to 1920 period, to 15,1% in 1990, and an increase in the industrial sector from 8% over the period 1910 to 1920, to 32,1% in 1991, have major implications for employment patterns in the longer term because a different set of work force competency is demanded.*

To adhere to the demands of realities sketched in the quotation, new curricula must not ignore the fact that the **knowledge** and **skills base** of the learning, working and unemployed population has to be massively upgraded. The previous apartheid system though, did not provide all South African learners with opportunities for personal development and empowerment, resulting in the failure to provide the country with a large, **productive and skilled work force** needed to match the needs of employment (HSRC, 1995:6). The education system as it was before 1994 could be regarded as a cornerstone of apartheid between the White, Black, Coloured and Asian races. In 1953, the Bantu Education Act imposed separate education systems for the different racial groupings, with strong state control. The Act regulated access to schools, grade 12 exit level examinations and partly different subject syllabi for history and literature for the different cultural groups. A strong top-down system was maintained, based on traditional curriculum philosophies which were described in Sections 2.3.1, 2.3.2 and 2.3.3.

The belief that South Africa needed **national standards** for education and training grew in the late 1980s and was induced by a range of influences. The main internal driving forces can be summarised as follows:

- ***Counteracting the former system:*** A need existed to abolish the consequences of previous curricula in terms of outcomes, content, curricular structure, access to education, teaching and assessment strategies. The New South Africa is committed to democracy where equal learning opportunities are available.

- ***Bridging the gap between education and training:*** A need existed to abolish the idea that education which was more academically orientated was superior to training which was labour orientated. Labour organisations have pushed for an integrated system of education and training.

- ***Preparing South Africans for the 21st century:*** The reality of globalisation and changes in work organisation must be addressed through new curricula.

These major driving forces will be described in more detail in the discussion below. Different influences stimulating the direction towards national standards came from a diversity of backgrounds and priorities. Some of the prominent influences and challenges included the following:

- The need to create an equitable system of education and training which serves all South Africans well. Such a system would need to accommodate those learners in conventional schools, colleges and training programmes, as well as the needs of learners who have not enjoyed formal education and training.

- The anticipation of major changes in society which required new ways of organising instruction in order to establish a working democracy – not least the "production of knowledge".

- Increasing dissatisfaction in trade, industry and labour because the education and training systems were far behind their international counterparts. There was an urgent need to provide workers with the competencies required in a technologically demanding global economy, with rapidly changing forms of work demanding multi-skilled workers.

- International trends where the received Western curriculum was being challenged by demands for greater modern relevance and accountability, and thus for national standards which would encourage the achievement of outcomes. Focusing on the demand of accountability, the document Draft Recommendations for the Development and Implementation of Assessment Policy (Department of Education, 1997c:9) argues that

  > *since the 1980s there has been an increased demand from taxpayers and funders for visible monitoring and accountability ... Margaret Thatcher and Ronald Reagan, have played a leading role in this movement, insisting on value for money and measurable outcomes....With large proportions of national budgets devoted to education, demands for increased accountability have led to systematic and regular assessments, both of individual learners and of the overall education system [systemic evaluation] in countries which previously did not have these features.*

- Frustrations caused by complex and disarticulated systems of certification that created artificial barriers to progress in learning and work.

- Findings, particularly in the evaluation of adult education, indicated that programmes were lacking in direction, purpose and status and therefore failed to provide substantive benefits for learners.

- Overemphasis on the learning of information rather than the ability to access and utilise it. The lack of ability to apply critical thinking and problem-solving skills and to transfer skills to different contexts.

- An artificial and exaggerated divide between academic-theoretical and vocational-practical learning, where academic study is generally perceived to be of higher status.

- Inadequate general education combined with narrow vocational training delivering individuals lacking the ability to adapt to a rapidly changing economy (Department of Education, 1997c:7-9; HSRC, 1995:5-6, SAQA, 1997:2 and Department of Education, 2000b:12-13).

To address these problems and set reform in motion, the South African government accepted OBE as the mechanism for reform for the very reason to address the broad political, socio-economical and vocational issues mentioned above. Not only in South Africa, but also in other countries, such as different states and districts in the United States, as well as in Canada, Australia and New Zealand, attempts have been made to reengineer the traditional education systems according to OBE principles. Also in Europe, OBE serves as a popular approach to initiate reform. In the Netherlands, as well as Flanders, former curricula are redesigned to include "*eindterm*" or "*kerndoelen",* which are outcomes (De Corte, 1999:8).

It is important to note that outcomes-based education has many different forms. For example, Spady (1994a,b) distinguished between three broadly defined approaches, namely the traditional approach, transitional approach and the transformational approach.

Traditional OBE: In traditional OBE, the existing curriculum is the starting point to formulate outcomes, rather than the other way around. Just like objectives, outcomes are directly derived from the existing syllabus content in traditional subjects. Educational planning and implementation, in other words, are based on subject matter categories, also referred to as a disciplinary approach. There is no clear picture of the long-term outcomes of learning or of how they relate to each other in society. These outcomes are therefore not generalisable to other Learning Areas or contexts outside of school (Spady, 1994a:18-19).

Transitional OBE: In transitional OBE educational planning and implementation focuses on higher order competencies and their role in connecting and potentially integrating unconnected, content-focused curriculum areas. The term "interdisciplinary" characterises this approach (Spady, 1994b:193). Less emphasis is given to particular kinds of knowledge and information. Curriculum design processes start with outcomes and not with the existing syllabi in mind. These outcomes are "*relatively complex... are generalizable across content areas and require substantial degrees of integration, synthesis, and functional application*" (Spady, 1994a:19).

Transformational OBE: When the curriculum is designed around long-term outcomes related to the future life-roles of learners, it is said to be transformational (Spady, 1994a). South Africa has opted for transformational OBE, which is the most radical and perhaps complex of the three types. According to this type of OBE, the existing education system and curriculum, impede the development of a new society and do not meet the long term, real life needs of the learners. In South African society, where there is a strong push for rapid social change, transformational OBE seemed to be the most attractive option. This approach has very similar tendencies and aims with education as the reconceptualist education philosophy which was described in Section 2.3.4. The critical outcomes, which will be treated in detail in Section 2.4.3.2, describe the package of competencies in terms of knowledge, skills, attitudes and values which learners will need to be lifelong learners. No thought is given to the old curriculum whatsoever. Spady (1994a:19) emphasises that transformational outcomes "*require the highest degrees of ownership, integration, synthesis, and functional application of prior learning because they must respond to the complexity of real-life performances*". Spady (1998:26-27) makes it very clear that these outcomes are significant performance abilities and not just content, scores, averages, percentages or credits. Spady (1998:26) is adamant that these outcomes must drive curriculum, not the other way around.

To make the OBE approach a practical reality, a system was created as a vehicle to operationalise the new approach. From the challenges, demands, and problems mentioned earlier, a prominent need developed to make education and training more flexible, efficient and accessible as was suggested by the Department of Education (1995a:15):

Successful modem economies and societies require the elimination of artificial hierarchies, in social organisation, in the organisation and management of work, and in the way in which learning is organised. They require citizens with a strong foundation of general education, the desire and ability to continue to learn, to adapt to and develop new knowledge, skills, and technologies, to move flexibly between occupations, to take responsibility for personal performance, to set and achieve high standards, and to work cooperatively.

The idea being proposed for transforming education and training in South Africa envisages the integration of education and training into a **single, coherent** and **unified approach** to make it possible for all learners to achieve national qualifications through a variety of mechanisms and delivery systems: This integration principle is to be achieved by means of the **National Qualification Framework (NQF)** (HSRC, 1995:5-6 and SAQA, 1997:2). It is to this aspect that the discussion now turns.

2.4.2 The shaping of the National Qualifications Framework

Through extended contestation, policy formation, debate and research in the early 1990s, the concept of a National Qualification Framework (NQF) emerged. The NQF is a systematic way of describing the way in which the South African education system will be structured, and a mechanism by which all qualifications can be standardised and registered. As in England, Scotland and Australia, the NQF has its origins in the industrial, service and labour sectors. In South Africa, the concept of a NQF was notably developed by the initiatives published in the following documents:

- The Education Renewal Strategy (ERS, 1992) and a Curriculum Model for South Africa (CUMSA, 1993).

- The National Education Policy Investigation (NEPI, 1992).

- The National Training Strategy Initiative from the National Training Board (NTB, 1994).

- The Implementation Plan for Education and Training (IPET, 1994).

- The Centre for Education Policy Development (CEPD, 1995).

The above-mentioned documents contributed intensively towards the publication of the White Paper on Education and Training on 28 February 1995, which spelt out that

> *an integrated approach to education and training, linked to the development of a new National Qualifications Framework (NQF) based on a system of credits for learning outcomes achieved, will encourage creative work on the design of curricula and the recognition of learning attainments wherever education and training are offered (Department of Education, 1995b:15).*

From the quotation it becomes apparent that national standards, which will be formulated as learning outcomes are inextricably linked to the NQF in that the standards will be housed within the NQF after registration by the South African Qualifications Authority (SAQA) (Department of Education, 1995b:12). SAQA with its developmental and management role of the NQF, will have to assure that the vision of the NQF is actualised by means of the principles underpinning the NQF. The underpinning principles will be addressed in the next section.

2.4.2.1 The vision of the NQF and key principles underpinning the NQF

Guiding the transformation in the sphere of education and training is a vision of **lifelong learning** for all learners (HSRC, 1995:10). Lifelong learning in this particular frame of reference has a more technical meaning in the sense that learners should have access to a variety of learning opportunities. It means that learners must be able to decide when, where and how they want to study and they must be able to progress readily between various areas, levels and providers of learning.

Using lifelong learning as a point of departure when discussing learning progression, means that learners will not be locked into one learning compartment or another. While learning through a variety of mechanisms and a multiple delivery systems, learners take with them recognised credits for learning that has already taken place – called recognition of prior learning (RPL).

The vision of lifelong learning should not only be interpreted on a technical level, but it should also be envisaged on a meta-level by every person and organisation involved in education and training. This meta-vision implies that curricula and learning programmes should empower learners to become competent learners who reflect knowledge, skills, attitudes and values, which are necessary to set in motion and sustain **a culture of lifelong learning**. As situations and demands change, competent learners will be able to exert control over their own learning. General competencies, as opposed to task specific competencies, which do not depend on content as such, are **transferable** from one context or problem situation to another. The result being a **flexible** learner, worker and citizen who can adjust effectively to changing personal and career needs.

The vision of lifelong learning will become a reality only when the NQF is guided by the following set of principles developed after intensive research by the National Training Strategy Initiative. This set of principles is reflected in Table 2.1 and is drawn up from two documents, *"Ways of seeing the NQF"* (HSRC, 1995:91-93) and *"Outcomes-Based Education in South Africa"* (Department of Education, 1997e:14-15).

Table 2.1: Principles underpinning the National Qualifications Framework

PRINCIPLE	THE NATIONAL QUALIFICATION FRAMEWORK MUST:
Integration	establish the basis for an **integrated approach** as part of a human resources development policy aimed to integrate theory (academic) with the practical (vocational).
Relevance	**be** and **remain responsive** to national economic, social and political development needs.
Credibility	have national and international **value** and **acceptance.**
Coherence	work within a **consistent framework** of principles and certification which allows learners to link credits into a meaningful learning or career pathway.
Flexibility	allows for **multiple pathways** leading to the same learning ends.
Legitimacy	provide for the participation of **all national stakeholders** in the planning and co-ordination of standards and qualifications.

Access	provide **ease of entry** to appropriate levels for all prospective learners in a manner which facilitates progression.
Progression	ensure that the framework of qualifications permits individual learners to **move through** the **levels** by accumulating appropriate combinations of credits.
Portability	enable learners to **transfer** their **credits** from one context to another.
Articulation	provide for learners, on successful completion of accredited prerequisites, to **move between components** of the delivery system.
Recognition of prior learning	through assessment, give **recognition to learning** which **has already been acquired** in different ways, e.g. through life or work experiences.
Guidance of learners	provide for the **counselling** of learners by individuals who meet nationally recognised standards for education, training and development practitioners.

The NQF with its vision of lifelong learning underpinned by guiding principles will serve to encourage the creation of new and flexible curricula, to promote quality learning standards and to monitor and regulate the quality of qualifications.

2.4.2.2 The structure of the National Qualifications Framework

In the traditional, formal school system, **core curricula** featured and although goals, aims and objectives were stated as points of departure, core curricula were content-based. This means that core curricula were organised in terms of prescribed and/or elective subjects which were offered at specific stages (age groups) for fixed periods of time, in a particular institution of learning. Learners' progress from one standard to the next depended on the extent to which learners had mastered the required subject content. Continuous assessment took place at various points during the year and finally at the end of a year in formal summative year-end examinations (Department of Education, 1995e:5).

The NQF together with Curriculum Frameworks differ from the core curriculum model and brought a completely new dimension to curriculum and programme development and management. Curriculum Frameworks may be regarded as philosophical and organisational frames of reference with the following main functions and implications for curriculum endeavour:

- They provide norms and standards for curriculum development and design. They do not prescribe content to be mastered.

- They spell out principles for curriculum development and design.

- They provide guidelines for organising teaching and learning.

- They specify essential, generic outcomes for teaching and learning.

- They describe the areas or fields of learning which are regarded as essential for teaching and learning.

- They suggest approaches to be adopted in evaluating learner progress or assessing learner outcomes.

- They create opportunities for innovation in that they allow for the development of flexible, relevant learning programmes which will take into account the particular needs, constraints and realities of a particular group of learners, thus contextualising learning. The term "learning programmes" is defined as consisting of competencies specific to a Learning Area (specific outcomes), as well as possible learning materials and methodology by means of which learners may achieve predetermined learning outcomes.

Although learning providers, normally operating from a provincial level, have the mandate to develop learning programmes which contextualise learning outcomes in selected content areas, it is desirable to **identify common key elements of the basic context** at a national level. The reason is a practical one. Learners who move between provinces must follow broadly similar programmes in terms of "*the general coverage of concepts and content, for example in Mathematics, Geography or History*" (Department Education, 1995b:48). The details of themes and actual content can be decided on at provincial level (Department of Education, 1997b:3 and Department of Education, 1995b:5).

With the broad functions of the National Qualifications Framework and other Curriculum Frameworks in mind, the structure of the NQF underpinning all Curriculum Frameworks will be discussed now. The NQF is an eight level qualification framework with three distinguishable bands. Figure 2.2 depicts the three bands, levels and sub-levels, as well as learning providers at various levels.

Figure 2.2: A proposed structure for National Qualifications Framework

NQF LEVEL	Band	Types of Qualification and Certificates	
8	Higher	Doctorates Further Research Degrees	
7	Education	Higher Degrees Professional Qualifications	
6	and	First Degrees Higher Diplomas	
5	Training Band	Diplomas Occupational Certificates	
Further Education and Training Certificates			
4	Further Education	School/College/Training Certificates Mix of units from all non-governmental organisations	
3	and	School/College/Training Certificates Mix of units from all non-governmental organisations	
2	Training Band	School/College/Training Certificates Mix of units from all non-governmental organisations	
General Education and Training Certificates			
1	General	Senior Phase	ABET Level 4
	Education	Intermediate Phase	ABET Level 3 ABET Level 2
	and	Foundation Phase	ABET Level 1
	Training Band	Pre-school	• Formal schools • Occupation/Workbased training • Churches/Night schools Non- governmental organisations

- ***The first band: The General Education and Training band*** **(GET)**

This band represents 9 years of compulsory education, ranging from grade 1 to 9. Two distinct sectors present themselves in this band. The one sector is formal compulsory education, consisting of the Pre-school Phase (grade 0), Foundation Phase (grade 1-3), the Intermediate Phase (grade 4-6) and the Senior Phase (grade 7-9), culminating on level 1 after completion of grade 9. Curriculum 2005 is the national curriculum which is currently being implemented and phased in this band. The other sector is Adult Basic Education and Training (ABET) which also culminates on level 1 on the NQF. ABET comprises of ABET sub-levels 1 to 4. When exiting level 1, the qualification obtained is referred to as a General Education and Training Certificate (GETC).

- ***The second band: Further Education and Training (FET)***

  This band proceeds from level 2 through to level 4, which may be compared with grade 10 to grade 12. When exiting level 4, the qualification obtained is referred to as a Further Education and Training Certificate (FETC).

- ***The third band: Higher Education and Training (HET)***

  This band comprises of levels 5 to 8. Various types of qualifications such as certificates, advanced certificates, diplomas and degrees may be registered on these levels.

As mentioned in earlier paragraphs, nationally agreed-upon outcomes are formulated for the compulsory school years from grade 1 to 9, as well as assessment criteria which will assist an educator in determining whether outcomes have been attained. In the FET and HET bands, qualifications may be registered either as "whole qualifications" (e.g. a BA) or in terms of an approved grouping of components known as unit standards. The format of unit standards will be attended to now.

(i) Unit standards

A unit standard is the smallest entity registered and assessed on the National Qualifications Framework on a specific level. A unit standard is outcomes-orientated and is expressed in terms of learner capabilities such as knowledge, abilities, skills and attitudes that are to be demonstrated by individual learners. To each unit standard an amount of **credits** is allocated which a learner can accumulate when he/she can demonstrate the mastering of an outcome formulated in a unit standard. A unit standard is *not* a conventional list of content items (HSRC, 1995:16).

The purpose of a unit standard, according the SAQA Act (number 0208/96) (SAQA, 1997:8), is to provide

- a learner's guide document
- an assessor's document, and
- an educator's guide for developing and preparing learning material.

A unit standard should include the following information to serve its purpose :

- A unit standard title.
- A South African Quality Authority approved logo.
- A unit standard number.
- A unit standard level on the NQF.
- The credit which may be obtained after mastering the outcomes formulated in the unit standard.
- The field (context) and sub-field of the unit standard.
- The issue date.
- The review or expiry date.
- Purpose of the unit standard.
- Prior learning assumed to be in place before the unit standard is commenced, also called entry assumptions.
- Specific outcomes, which are contextually related and which will be assessed.
- Assessment criteria as well as embedded, underpinning knowledge, which might *inter alia* include background knowledge, cognitive frameworks, assumptions and values essential for completion of the unit standard.

- Range statements as a general guide for the scope, context, degree of complexity and level being used for this specific unit standard.

- Accreditation and moderation processes which had as its purpose the enhancement of credibility and principles such as portability and mobility, thus assuring that a "standards drift" does not occur across different assessment sites.

- A notes category which refer to the following information:

  - A statement indicating all the **critical cross field outcomes** which may be actualised by this particular unit standard. It must be mentioned that critical cross field outcomes underpin the whole NQF and every unit standard should strive for the actualisation of as many as realistically possible critical cross field outcomes.

  - Essential **embedded knowledge** should be addressed in this section if it has not been addressed under the category of assessment criteria.

  - May include any other **supplementary information** on the unit standard, for example it may refer to all the other specific outcomes which are supported by this specific outcome (HSRC, 1995:68-77 and SAQA, 1997:9).

Since unit standards are the smallest entities which may be assessed, they are also the smallest entities which contribute to the accumulation of credits by a learner. The free accumulation of credits though, must not lead to learners finding themselves with pointless collections of credits with no linkage to possible qualifications and high priority needs of society, industry and economy. This free-market approach to culmination of credits necessitates thorough reflection on the relationship between unit standards, credits and the construction of qualifications.

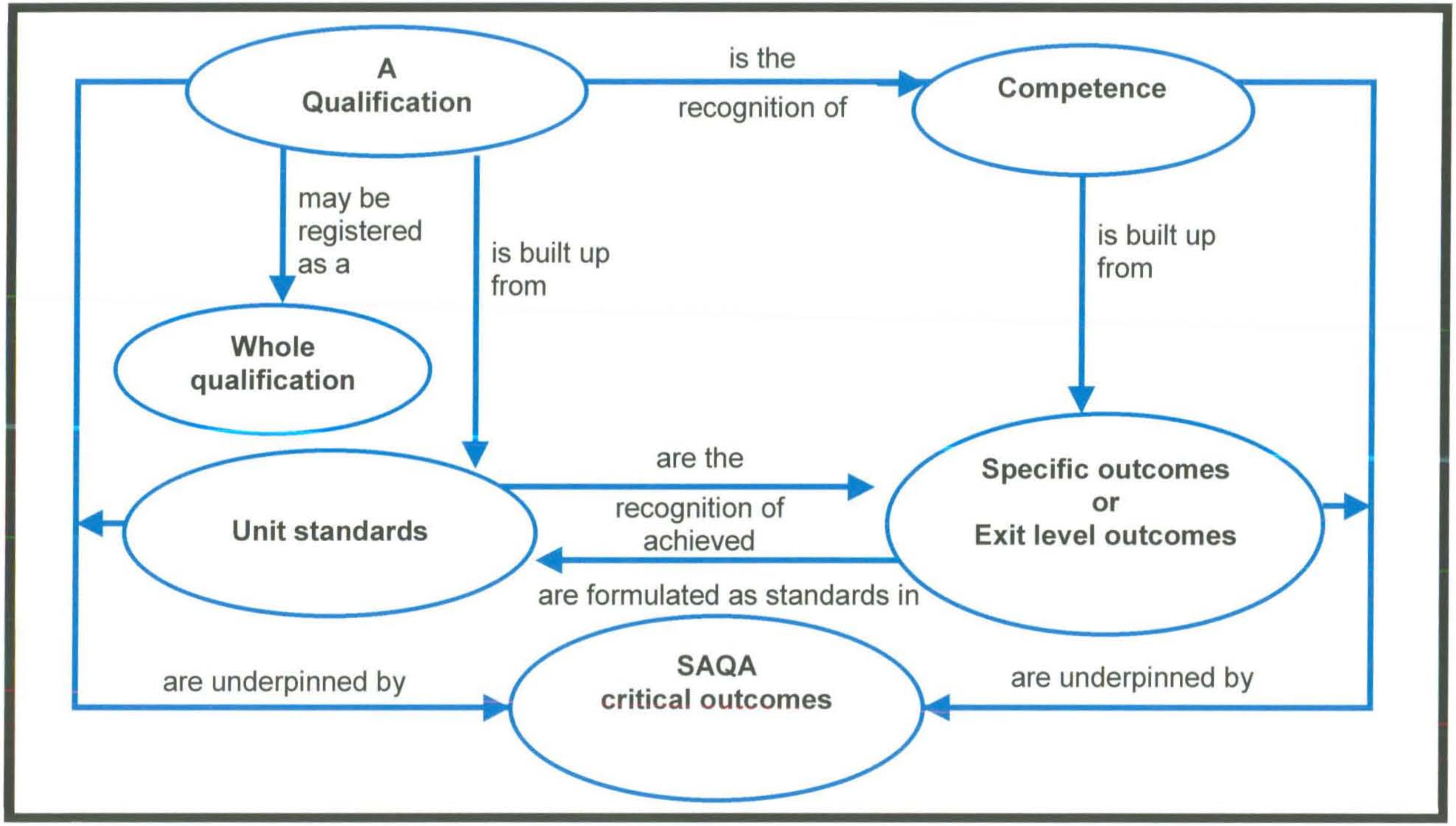
(ii) The relationship between unit standards, credits and qualifications

The building components of qualifications are indeed unit standards, while unit standards describe the specific context related outcomes to be achieved by a learner. As learners meet the criteria which indicate that they have mastered specific outcomes described in a unit standard, they accumulate credits towards a specific qualification. When they have collected the **minimum number** and **combination** of credits, they have achieved the defined degree of competence in a particular field or Learning Area and receive a qualification (Department of Education, 1996a:26). A qualification has been defined by The SAQA Act (SAQA,1995, clause1:viii) as follows:

> *Qualification means the formal recognition of the achievement of the required number and range of credits and such other requirements at specific levels of the NQF as may be determined by the relevant bodies registered for such purpose by SAQA.*

The following figure illustrates the **relationships** between the relevant concepts as shown in Figure 2.3:

Figure 2.3: The relationship between qualifications, unit standards and outcomes



Different qualifications may be constructed by clustering combinations of registered unit standards on different levels. Each unit standard will contribute towards a specific amount of credits needed for different types and levels of qualifications. It is important to note that whole qualifications, which are not broken down in unit standards, may also be registered on a NQF level as was mentioned earlier. This is the main route which have been taken by South African universities who deliver whole qualifications already. The type and level of qualifications will be determined on the basis of the total number and levels of credits required in accordance with the following criteria (SAQA, 1997:15-16):

National Certificate: A minimum of 120 credits are needed of which 72 of the credits shall be at or above the level at which the certificate is registered on the NQF.

National First Diploma: A minimum of 240 credits are needed of which a minimum of 72 credits shall be at level 5 or above on the NQF.

National First Degree: A minimum of 360 credits are required of which a minimum of 72 credits shall be at level 6 or above on the NQF.

The South African Qualifications Authority (SAQA) has accepted

> *a credit system on the basis of one credit equalling 10 notional hours of learning, motivated in context in each case (SAQA Act, Decision 0209/96, 1995:10).*

For a National Certificate requiring a minimum of 120 credits, a learner will roughly need 1 200 hours of learning time, including contact teaching, individual study and practice. One credit is equal to ten notional hours of learning. The relationship between unit standards, qualifications and the accreditation system will have to be operationalised within generic broad fields of learning. It is the classification of these broad learning fields which will be addressed in the following paragraph.

2.4.2.3 Organising fields and Learning Areas

The National Qualifications Framework is divided into twelve organising fields which are the key elements of the organisational mechanism of the NQF. The purpose of the organising fields is to enable the standards setting process (SAQA, 1997:8). Since these fields may be viewed as representative of the categorical structure of the real life world, they are based on a hybrid of both subject disciplines and occupational areas. Since these serve as organising tools for the NQF, they are labelled "organising fields" (SAQA, 1997:8).

The final 12 organising fields identified by SAQA, as well as possible sub-fields as categorised by the Human Science Research Council (HSRC, 1995) are given in Table 2.3.

Table 2.2: The organising fields and sub-fields

12 ORGANISING FIELDS		SUB-FIELDS
1	Agriculture and nature conservation	Agriculture, forestry, fisheries, horticulture, nature conservation
2	Culture and arts	Visual arts Performance arts: stage, musical, etceteras
3	Business, commerce and management studies	Financial, administration, commercial practice, property, marketing, leadership, management, supervision
4	Communication studies and language	Communication Languages
5	Education, training and development	Education, training and development
6	Manufacturing, engineering and technology	Design, construction, maintenance, production and manufacturing Mobile equipment and materials handling
7	Human and social studies	Histories, geographies/economics, individuals, societies Religions
8	Law, military science and security	Law, military science and security
9	Health sciences and social services	Medical and dental (animal, human) Sport, recreation, food and nutrition, fire and safety
10	Physical, mathematical, computer and life science	Pure and applied mathematics, computer studies, life sciences. All other natural sciences

11	Services	Hospitality and tourism, beauty technologies, publishing and binding, information storage and archiving, wholesale and retail
12	Physical planning and construction	Architecture, building and construction.

(SAQA, 1999b:5, SAQA, 1997:8 and HSRC, 1995:60-61)

Emanating from the 12 organising fields are the **eight Learning Areas** which will organise learning in the Senior Phase and the Further Education and Training (FET) Band. These Learning Areas have been collapsed into five Learning Areas for the Intermediate Phase, and further into three Learning Areas for the Foundation Phase. The following table indicates the Learning Areas which will be implemented in the different phases, as well as the notional time, expressed as a percentage, which has been allocated to each learning area by the central Department of Education. It will be noted that a percentage for "flexible time" has been built into the allocation of notional times, to allow for flexibility where time is needed for inter alia more enrichment or remedial work in a specific Learning Area or even for school or other institutional activities.

Table 2.3: The learning areas for the General and Further Education and Training bands

Learning areas		Notional time
Foundation Phase		
1	Literacy	25 %
2	Numeracy	25 %
3	Life skills	25 %
	– Flexible time	25 %
Intermediate Phase		
1	Language, literacy and communication	35 %
2	Mathematical literacy and numeracy	15 %
3	Natural sciences and technology	15 %

4	Human, social, economics and management sciences	15 %
5	Arts and culture, life orientation	15 %
	– Flexitime	5 %
Senior Phase and Further Education Band		
1	Language, literacy and communication	20 %
2	Mathematical literacy and mathematical sciences	13 %
3	Natural sciences	12 %
4	Life orientation	10 %
5	Technology	10 %
6	Human and social sciences	10 %
7	Economics and management sciences	10 %
8	Arts and culture	10 %
	– Flexitime	5 %

(Department of Education, 1997a:11 and Department of Education, 1997b:1-3)

The latest report of the Review Committee on Curriculum 2005 which was released on 31 May 2000, will be handed to the Minister of Education Professor Kader Asmal. This report recommends that the eight Learning Areas should be reduced to six (languages, science and technology, social sciences, arts and culture and life orientation) with three learning programmes in the Foundation Phase and six in the Intermediate and Senior Phases (Executive Summary on Curriculum 2005, 2000:4-5). Since these are recommendations which the Minister will still have to react upon, this study will not address or comment on the emerging issues.

It was proposed by SAQA that qualifications in the FET band (level 2-4), comprise of 120 credits. SAQA also stipulates that that the 120 credits shall be divided into three categories of learning, namely fundamental, core and elective. These three categories will each carry a number of credits from the different Learning Areas, as indicated in the following tables (Department of Education, 2000b:27-30):

Fundamental learning

Fundamental learning comprise all the knowledge, skills and attitudes that are the foundation for all learning at the level concerned. These include language and communication, life skills and mathematical literacy. The minimum number of compulsory credits for the fundamental category of learning will be 45. Table 2.4 gives a layout of the credits which will be allocated to the various Learning Areas in this category.

Table 2.4: Credits and Learning Areas for the category of fundamental learning

Learning Areas according to SAQA	**Credits**
Languages and/or communication	20
Mathematical Literacy	10
Learning Areas/sub-fields/courses proposed by the Department of Education	**Credits**
Life Skills, for example: Health and Sexuality Education Responsible Living / Self Management Entrepreneurial Skills Citizenship Education Information Technology Literacy Skills	15
TOTAL COMPULSORY CREDITS FOR THE FUNDAMENTAL	**45**

(Department of Education, 2000b:27):

According to SAQA, a minimum of **20 credits** from the field of **Communication Studies and Language** must be included in this category of the qualification. In pursuit of equity, multilingualism and the redress of past language discrimination, it is proposed that the language of learning and teaching and at least one other official language, be offered and be given equal weighting in terms of credits. The study of more than two languages should be encouraged.

SAQA further stipulates that a minimum of **16 credits** is required from the sub-fields of Physical, Mathematical, Computer and Life Sciences, to be known as Mathematical Literacy. The Ministry however, only allocated 10 credits for this category. Mathematical Literacy deals with qualitative and quantitative relationships of space and time. It includes a critical awareness of the use of numbers, an appreciation of the space we live in and the ability to control personal finances. In other words, it includes mathematical skills required for everyday living in the 21^{st} century as a responsible citizen. It equips learners with the basic knowledge, skills and attitudes that would prepare them for effective participation in a society in which scientific and technological applications play an increasingly important role. This important, compulsory component of all qualifications will enable learners to exit with the competencies that will enable them to continue to learn and apply the mathematics they will need throughout their lives, using the 'special language' of mathematics to communicate their everyday experiences.

The category Life Skills has been included as a compulsory component of Fundamental learning, and includes outcomes for citizenship education (including human rights), health and sexuality education, responsible living and self-management, information technology literacy and entrepreneurial skills.

Core learning

Core learning includes the specific, core knowledge, skills and attitudes required for the completion of a particular qualification. It is compulsory learning that is contextually relevant to the purpose of the particular qualification and provides the depth and specialisation that are required for the purpose of the qualification.

Table 2.5: Credits, Learning Areas and sub-fields for the category of core learning

Learning Area or sub-fields	Courses	
2 or more sub-fields of any field.	Physical Science Biological Science Electrical Design Electrical Theory Computer Applications Mathematics Electrical Cabling Other sub-fields	
TOTAL COMPULSORY CREDITS		**50**

(Department of Education, 2000b:29):

The minimum number of courses selected for the core must be **two** (depending on the requirements of the qualification) and must total a minimum of 50 credits. The depth required for a particular qualification is best met by restricting the selection to the same field or occupational cluster.

Elective learning

Elective learning provides additional, optional credits, which may be of personal interest or professional relevance, or which open the door to a range of possible career and occupational choices. The **elective** serves to further encourage broad, non-specialised studies and to provide learners with the opportunity to make the transition to working life. Accordingly, the chance to introduce some breadth into the qualification by introducing competencies that broaden the core whilst providing for other career or occupational directions, arises within this category.

The elective can also serve to reinforce the required specialisation for the purposes of the qualification, without prejudicing the need for breadth. Extra competencies that support the courses covered under the core may fulfil the need for specialisation.

Table 2.6: Credits, Learning Areas and sub-fields for the category of elective learning

Learning Area or sub-field	Courses	
1 or more sub-fields of any field.	Photography Bookkeeping Skills Mechanical Design Engineering Science Entrepreneurial Skills	
TOTAL COMPULSORY CREDITS		**25**

(Department of Education, 2000b:29):

Any number of courses may be selected from any of the twelve organising fields. A minimum of one course may be selected, totalling a minimum of 25 credits.

2.4.3 The outcomes-based approach: intentions and implications for curriculum development

The NQF and the curriculum guidelines developed as a result of the NQF, for example Curriculum 2005 and the above mentioned guidelines for the FET band, are intended to embody an outcomes-based approach to curriculum design, development and implementation.

2.4.3.1 What are the outcomes in an outcomes-based curriculum approach? An exploration and definition

An understanding of what is meant by an outcomes-based approach is crucial to the effective development and implementation of curriculum and learning programmes within an outcomes-based paradigm.

Concepts underpinning outcomes-based education are not new and have been in and out of favour. Outcomes-based education has it roots according to Killen (1998a:2) in **competency-based** education (Franc, 1978 and Burke, 1989), **programmed learning** (Lumsdaine & Glaser, 1960), **criterion-referenced assessment** (Masters & Evans, 1986) and in the educational **objectives** approach as described by Mager (1962) and Tyler (1950). Mpepo (1988:8) explains that criterion-referenced assessment is seen as a form of mastery learning, since it is strongly based on attaining specified objectives which are tested against the criterion stated in the objective. The **mastery learning** concept by Bloom (1956) also uses outcomes to describe learning in a systematic curriculum process. Mastery learning added the notion that most learners can be effective, successful learners when provided with adequate resources and learning opportunities (Dlugosh, Walter, Anderson & Simmons (1995:178). Outcomes-based education as described by Spady & Marshall (1991), also focuses on principles of mastery learning which were implemented in entire school districts throughout the United States of America (Dlugosh, Walter, Anderson & Simmons, 1995:178).

The difference between aims, goals and objectives on the one hand and learning outcomes on the other will briefly be looked at now. Killen (1998a:3) makes the following comment in this regard:

> *The real issue is that statements of aims, goals and objectives describe the intent of some educational process. If these intentions are realised, the end product of the educational process can be referred to as an educational outcome. It is this link between intentions and results that is the heart of outcomes-based education. Statements of intent or statements of desired educational outcomes focus attention on the purpose of instruction, rather than on the content or learning experiences that are the vehicles for instruction.*

The difference between the intentions of the educational process (aims, goals and objectives) and the results of the educational process will be clarified in more detail in the following table:

Table 2.7: The difference between aims, goals, objectives and learning outcomes

Intentions with educational process	Results of the educational process
Aims, goals and objectives	***Learning outcomes***
Focus on what the teacher will do	Focus on what the learners will do
Describe the intention of teaching	Describe the results of learning
Focus on opportunities provided for learning	Emphasise how learning is used, especially how it can be applied in new areas
Involve estimating the amount that can be learned in a given period of time	Require flexible allocation of time

(Department of Education, Appendix E, 1996:2)

Comprehending the shift in focus from aims, goals, objectives to learning outcomes, it now becomes necessary to work towards a working definition of the term "outcome" from a curricular perspective. A list of definitions and/or descriptions of the term "outcome" as it manifests in the literature is given in the table below.

Table 2.8: Definitions and descriptions of the term "outcome"

TERM	DEFINITION/DESCRIPTION
Outcomes	"Are the results of learning processes, formal, non-formal or informal and refer to knowledge, skills, attitudes and values within particular contexts. Learners should be able to demonstrate that they understand and can apply the desired outcomes within a certain context" (Department of Education, 1997e:4).
Outcome	"Is that segment of a *unit standard* which is a statement of the required learner *capabilities* that must be demonstrated. Outcomes are specified by stated *performances* and *assessment* and *range* criteria (HSRC, 1995:2).
Learning outcomes	"A term used to describe the results or achievements of learning and teaching" (Department of Education, 1995c:3).

Outcomes	Culminating demonstrations of learning that occur in clearly defined contexts (i.e. settings and circumstances) and that really matter in the long run for learners (i. e. after their formal education is finished)(Spady, 1994b). Spady (1994b:1-3, 190) refers to the ultimate, culminating demonstrations of learning at the end of schooling or a course as "*exit outcomes*", while "*enabling outcomes*" are demonstrations that are the building blocks of more complex outcomes.
Outcome	"An attainment target ...identifying what a student is expected to learn" (Silvernail, 1996:48).

From these similar definitions and descriptions the following working **definition of an outcome**, for the purposes of this study may be formulated as follows:

- *A learning outcome is a predetermined demonstration or achievement of a learning process, which may include mastered knowledge, competence (abilities, skills and techniques), attitudes and values.*

- *Learning outcomes may be generic or context specific in nature.*

- *Transformational outcomes are formulations of life roles which learners are expected to demonstrate and which matter in the long term in their lives and world of work.*

Spady (1994b:2) however, does not agree that outcomes are values, beliefs, attitudes or a psychological state of mind. South African formulations of outcomes do however include these not always easy quantitatively measurable outcomes. Spady (1994b, 2) states that "*outcomes are what learners can actually do with what they know and have learnt – they are tangible application of what has been learnt*". For this reason he suggests that observable action verbs such as describe, explain, design or produce should be used instead of vague, non-demonstration processes like know, understand and believe. This however, does not mean that these processes are not important.

The term "competence" referred to in the working definition has been used ambiguously in the literature. Some of the terms often used interchangeably with competence are "skills", "ability", "capability", performance" and "outcomes". Regarding competence Zemke (1982:28) maintains the following:

Competency, competencies, competency models and competency based training are Humpty Dumpty words meaning only what the definer wants them to mean. The problem comes … from some basic procedural and philosophical differences among those racing to define and develop the concept and to set the way the rest of us will use competencies in our day-to-day training.

The formulator of this definition for an outcome, will clarify the meaning of competence in relation to the concepts "abilities", "skills" and "techniques".

i) The relationship between competence, abilities, skills and techniques

Different definitions of competence exist, ranging from adequately qualified to the capacity to produce job outputs at a level and quality relative to organisational restraints and demands. Competence is also demonstrated on different levels, as reflected in the use of terms such as "effective", "superior", "proficient", "appropriate" or "insufficient". Eraut (1998) has undertaken an in depth exploration of the concept. An appropriate definition, according to Eraut (1998:29), for the everyday public use of the term is "*the ability to perform the tasks and roles required to the expected standard".* This definition has the advantage that it can be applied to a professional at any stage in their career and not only to a newly qualified. The expected standard referred to in the definition will obviously vary with experience and responsibility and will take into account the need to keep up to date with changes in practice (Eraut, 1998:129). During the 1970s, competency-based training focused on the achievement of competencies which were assumed to constitute competence in one particular job. Job analysis, task analysis and skills analysis provided detailed descriptions of a job which could then be used to provide training which exactly matched it. McMahon & Carter (1990:40, 49) describe a job, task and skills analysis as follows:

An investigation into the current job (what is?) and the future job (what *ought to be?). A job analysis breaks the job down into a series of activities and analyses the relationship between each of the activities in the job. These activities are in turn broken down to duties and tasks (and sub-tasks where appropriate). Because of the changing nature of work it is imperative a job analysis should look at existing duties-tasks-sub-tasks (descriptive) and future duties-tasks-sub-tasks (normative). A job-analysis …can be used as base information for job-design and the reorganisation of work patterns.*

A skills analysis …is a second level analysis which is concerned with identifying the key competencies required to perform the duties and tasks identified through the first level (job) analysis described earlier. A skills analysis is about describing what skills an employee needs to acquire to be competent in a particular job.

McClelland (1973) suggested a job and skills analysis which focus on training beyond the threshold of merely adequate performance development. He defines competency as "*an underlying characteristic of an individual that is causally related to criterion-referenced effective and/or superior performance in a job or situation*" (Eraut, 1998:133). The underlying characteristic referred to indicates that competencies are ways of thinking or behaving which generalise across situations and endure for a reasonably long period of time. Fletcher (1991:32) also refers to the generalisability of skills in his description of competence as "*a wide concept which embodies the ability to transfer skills and knowledge to new situations within the occupational area*". Spencer & Spencer (1993) published a Competency Dictionary based on generic and transferable aspects of competence. The twenty most common competencies are presented in Table 2. 6:

Table 2.9: The twenty most common competencies in Spencers & Spencers' (1993) Competency Dictionary

Achievement and action	**Helping and human service**
Achievement orientation	Interpersonal understanding
Concern for order, quality and accuracy	Customer service orientation
Initiative	

Information seeking	
Impact and influence Impact and influence Organisational awareness Relationship building	**Managerial** Developing others Directiveness/assertiveness and use of positional power Teamwork and co-operation Team leadership
Cognitive Analytical thinking Conceptual thinking Technical/professional/managerial expertise	**Personal effectiveness** Self-control Self-confidence Flexibility Organisational commitment

Note the similarities between these common competencies and the SAQA critical outcomes which will be discussed in Section 2.4.3.2. The Norms and Standards for Educators Policy (Department of Education, 2000a:10-11) describe the applied competencies which have to be demonstrated by educators. Applied competence is defined as a learner's demonstrated ability in an authentic context, to consider a range of possibilities for action (practical), and based on an understanding of the underpinning knowledge and thinking (foundational), to adapt to changing or unforeseen circumstances (reflexive) (Department of Education, 2000b:48). The foundational, practical and reflexive competencies to be preformed by educators are described in terms of roles in the legislative documentation.These roles are explained in detail in Section 3.2.2.

The working definition of an outcome for this research refers to three kinds of competencies, namely abilities, skills and techniques. Slabbert (1996, 103-104) describes these competencies as follows:

- ***Abilities***

Abilities are at the core of training and education and provide the prerequisites for performing tasks in a learning, work and everyday situation. Abilities entail the basic, naïve reception of impressions from the direct environment such as for example hearing, looking and touching, as well as basic expressions of motor movements such as speaking, turning and running (Slabbert, 1996:103).

Abilities are expressed as **capabilities** when they are *operative in relation to specific content areas, contexts and value frameworks*. The HSRC (1995:1) suggests that the following format should be used when formulating capabilities: A learner at this level is capable of "………**ing"**. For example: The science learners are capable of gather*ing*, analyz*ing* and interpret*ing* data presented in a physics research article.

- ***Skills***

Skills entail the **execution of an ability guided by thinking** (the mind). *Communicating* an idea will be the skill when *speaking* is guided by the mind. Similarly, *listening* is the skill when *hearing* is guided by the intellect (Slabbert, 1996:103). More complex skills, such as problem-solving**,** analyzing, classifying, evaluating, comparing, decision-making, anticipating and others are vested in a combination of different abilities (Nisbet & Shucksmith, 1986:14-16).

- ***Techniques***

Many texts do not distinguish between skills and techniques, but for the purposes of this discussion the difference between skills and techniques will be explicated. A technique is executed when an **extension or addition** (like an instrument) of the human body is implemented in conjunction with an ability or skill. The skillful surgeon for example knows how to use an instrument like a scalpel to make an incision when operating on a patient. A journalist has mastered the technique of writing when he/she can use the skill of communicating and then typing what has been communicated on a personal computer.

In the South African process of restructuring education, two types of outcomes will drive and direct curriculum and programme development. The broad, generic outcomes referred to in the definition are labelled *"critical cross field outcomes",* while the context specific outcomes are labelled *"specific outcomes".* The following sub-section will explore these two types of outcomes.

2.4.3.2 Critical cross-field outcomes and the vision of lifelong learning

The critical cross-field outcomes represent the transformational outcomes which have been explained earlier in Section 2.4.1. The critical cross-field outcomes which have been adopted by the South African Qualifications Authority (SAQA) will underpin all learning, learning programmes and curricula in South Africa. These outcomes describe the characteristics and competencies that all South African learners should demonstrate regardless of their age, sex, profession and, status in society (Killen, 1998a:7). The "critical cross-field outcomes" will be referred to as "critical outcomes" in the discussions that follow.

The critical outcomes are instrumental in realising the vision of South African education, which is to prepare each individual learner to become a **lifelong learner.** The NQF will provide the system of progression and articulation in education which will make continued learning possible, but the critical outcomes describe the competencies needed to sustain a culture of lifelong learning. They encapsulate the real life roles which learners have to perform. Spady (1994a:21) suggested that there are ten life performance roles that require complex applications of many kinds of knowledge and all kinds of competence as people confront the challenges surrounding them in their social systems. Spady (1994b: 1994:69-71) suggests that five of the life performance roles deal with social and interpersonal performance roles that inherently involve interactions amongst people. These are the roles shown above the dotted line in Figure 2.4:

- Listeners and communicators should be able to comprehend and express ideas, information, intention, feeling, and concern for others in ways that are clearly understood and appreciated.

- Teachers and mentors should enhance the thinking, skills, performance orientations, and motivation of others through the mediation they provide, the counsel they give, and the example they set.

- Supporters and contributors should invest time, ideas, and resources to improve the quality of life of those around them.

- Team members and partners should contribute their efforts to collaborative endeavours and who seek agreement on goals, procedures, responsibilities and rewards, setting aside personal preferences in order to accomplished, anticipating roadblocks, and supporting the participation of others to achieve the results.

Below the dotted line are performance roles, inherently more technical and strategic in character. These are the roles that individuals potentially should carry out entirely on their own, but that also might involve others. These include:

- Learners and thinkers who should develop and use cognitive tools and strategies to translate new information and experiences into sound action. They might use their repertoire of knowledge and strategies to extend their capacities for successful action by assimilating, analysing, and synthesizing new ideas and experiences.

- Implementers and performers who should apply basic and advanced ideas, information, skills, tools, and technologies as they carry out the responsibilities associated with all life roles.

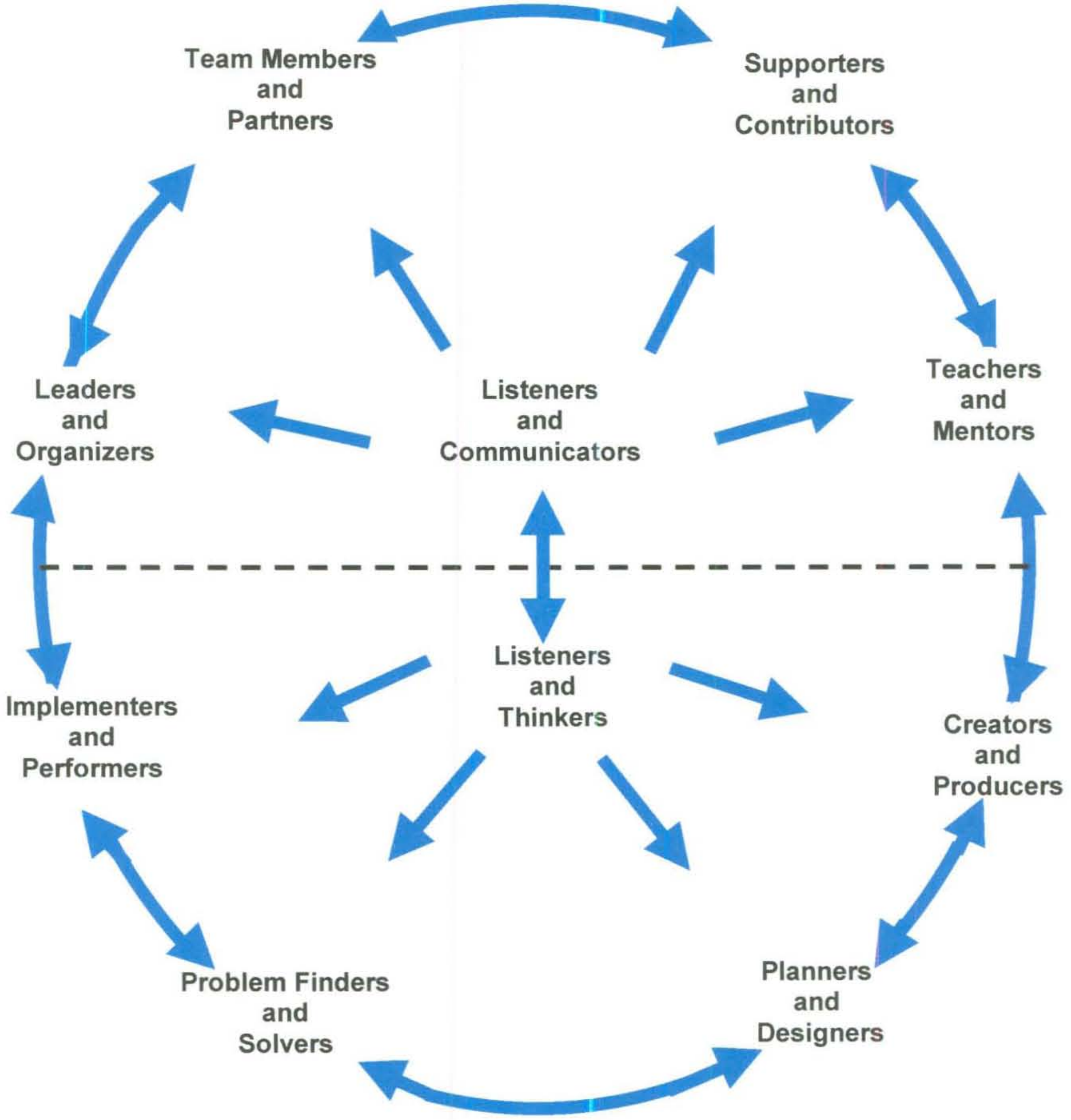
- Problem finders and solvers who should anticipate, explore, analyse, and resolve problems by examining their underlying causes from a variety of perspectives and then develop potential solutions to them.

- Planners and designers who should develop effective plans, methods, and strategies for anticipating and resolving issues and problems and for charting new courses of action.

- Creators and producers who should seek new possibilities for understanding or doing things and who translate hose possibilities into original, workable products or processes that change the working or living environment.

Figure 2.4 represents the life performance roles proposed by Spady (1994b).

Figure 2.4: Fundamental life performance roles



(Spady, 1994b:69)

In South Africa, these life performance roles are represented by the critical outcomes. There are eight critical outcomes of which the eighth includes "developmental outcomes" (Department of Education, 1997a:10-12). These outcomes, when mastered, will ensure that learners gain the knowledge, competencies, attitudes and values that will allow them to contribute to their own success, as well as to the success of their family, community and nation as a whole (Department of Education, 1997a:13).

Critical outcomes are, as the name indicates, not dependent on or restricted to a specific learning context. Research for identifying, selecting and defining critical cross-field outcomes for the South African context, was undertaken in *inter alia*, the United Kingdom, United States of America (USA), New Zealand, Australia and Canada. Overlapping sets of generic outcomes formulated by different countries will be compared in table format. The sets of generic competencies which will be compared include those from Australia and Scotland because they were used as a basis from which the South African critical outcomes were developed. The three sets of generic outcomes comprise of:

- Generic competencies proposed by the National Training Strategy Initiative Report which was written for the South African education and training sector (HSRC, 1995:102).

- The Australian Key Competencies identified by the Mayer Committee (Mayer, 1993). Initially seven Key Competencies were presented and later an eighth was added (Killen, 1998c:3-4). The parallels between the South African critical outcomes and the Australian Key Competencies are obvious.

- The Core Skills which underpin education and training in Scotland (Department of Education, 1996a: Appendix C).

Table 2.10: Comparison of generic competencies

NATIONAL TRAINING STRATEGY INITIATIVE REPORT GENERIC COMPETENCIES	AUSTRALIA'S KEY COMPETENCIES	SCOTLAND'S CORE SKILLS
Thinking about and using learning processes and strategies.		
Solving problems and making decisions.	**Solving problems**: the capacity to apply problem-solving strategies in purposeful ways, both in situations where the problem and th4e solutions are clearly evident and in situations requiring critical thinking and an creative approach to achieve an outcome.	**Problem-solving skills**: The ability to identify and clarify the nature of problems, to plan and implement strategies to address problems and to evaluate the effectiveness of strategies and solutions.
Planning, organising and making decisions.	**Planning and organising activities**: The capacity to plan and organise one's work activities, including making good use of time and resources, arranging priorities and monitoring one's own performance.	
Working with others as a member of a team/group/community.	**Working with others in teams:** The capacity to interact with other people on a one-to-one basis and in groups, including working as a member of a team to achieve a shared goal.	**Personal and interpersonal skills**: the ability to work independently and co-operatively with others and to use self-awareness and social-awareness to guide actions and decisions.
Collecting, analysing, organising and critically evaluating information.	**Collecting, analysing, organising g information**: the capacity to locate, sift and sort information in order to select what is required, present it in a useful way, and evaluate the information itself and the source and methods used to obtain it.	

Communicating ideas and information.	**Communicating ideas and information**: the capacity to communicate effectively with others using spoken, written, graphic and other non-verbal means of expression.	**Communication skills**: Ability to produce written and spoken communications appropriate for a range of purposes and audiences and to respond appropriately to a range of messages through reading and listening. with people at all levels.
Participating in society and democratic processes (legal, political, economic, social).		
Using science and technology critically to enhance control over the environment.		**Information technology skills**: The ability to use new technology to input, process, and output information and to perform basic operations.
Applying mathematical concepts and tools	**Using mathematical ideas and techniques**: the capacity to use mathematical ideas, such as numbers and space, and techniques, such as estimation and approximation for practical purposes.	**Numeracy skills**: The ability to use a range of fundamental arithmetical and mathematical, including artistic skills, to reach conclusions in a range of situations.
Understanding and using core skills, concepts and procedures that underlie the domains of human and natural sciences, arts, language and literature.		

These outcomes represent the knowledge, competencies, attitudes and values which are flexible and transferable from one context or problem situation to another. In these outcomes are embedded the seeds for cultivating lifelong learning ability. These outcomes encapsulate the generic competencies that would provide learners with the knowledge and skills that they need for their lives and before they enter the labour market. These outcomes are therefore the formulations of the life roles to be performed by learners. For some, for example, the one generic thinking skill which encompasses many other skills such as analysing, critical evaluating and decision-making, is **problem-**

solving.

The SAQA proposed critical outcomes are the following:

1. Identify and solve problems and make decisions using critical and creative thinking.

2. Work effectively with others as members of a team, group, organisation and community.

3. Organise and manage themselves and their activities responsibly and effectively.

4. Collect, analyse, organise and critically evaluate information.

5. Communicate effectively using visual, symbolic, and/or language skills in various modes.

6. Use science and technology effectively and critically showing responsibility towards the environment and others.

7. Demonstrate an understanding of the world as a set of related systems by recognising that problem-solving contexts do not exist in isolation (SAQA, 1997:7).

The following developmental outcomes should be read in conjunction with the above listed seven critical outcomes. In order to enhance the full personal development of a learner, as well as social and economic development at large, any programme of learning must make an individual aware of the importance of the following principles (SAQA, 1997:7):

1. Reflecting on and exploring a variety of strategies to learn more effectively.

2. Participating as a responsible citizen in the life of local, national and global communities.

3. Being culturally and aesthetically sensitive across a range of social contexts.

4. Exploring education and career opportunities.

5. Developing entrepreneurial opportunities.

The next section will distinguish in detail between critical outcomes and specific outcomes.

2.4.3.3 Specific outcomes

Specific outcomes refer to the specifications of what learners should be able to demonstrate in the various Learning Areas in Curriculum 2005. Currently there are sixty six (66) specific outcomes. These are included in Appendix 1 and are categorised for each Learning Area. In each of the Learning Areas a set of specific learning outcomes will describe what knowledge, skills, attitudes and values have to be demonstrated on certain NQF levels. The differentiation between various bands and phases of learning would be addressed by different levels of complexity in the

- **processes** learners engage in, and
- **methodologies** used for assessment, as well as in the **kinds of evidence** through which learners will demonstrate achieved outcomes (Department of Education, 1997a:15).

According to the Curriculum Framework for General and Further Education and Training (Department of Education, 1995a: 31) it should be acknowledged that not all learners learn at the same rate or in the same way and, therefore, learners should not be expected to attain the specific outcomes in the **same time** or at the **same place** or in the **same manner**. Learners should rather attain them over a broad range of learning experiences encountered over several grades and in a variety of contexts.

According to Killen (1998a:9) most traditional approaches to education are bound by *"this tyranny of time"*. A possible reason for time-based learning programmes Spady & Marshall (1991:72) suggest, is the fact that we are *"mired in an Industrial Age model governed by an Agricultural Age calendar"*. Time-based learning programmes rely on fixed learning opportunities and calendar closure, instead if on expanded opportunities and outcome closure (Spady, 1998:151). Barr & Tagg, (1995:13) also say that learning institutions will not necessarily be promoting learning, but teaching as long as they *"provide for the activity of teaching conceived primarily as delivering 50-minute lectures".* Killen (1998a:9) continues to say that time- and calendar-dominated curricula would be sensible only if all learners did learn and develop at the same rate, mastered different subjects at the same rate and were equally suited for a time-based education system. He also suggests that learning institutions, or rather teaching institutions as Barr & Tagg (1995) would label them, mainly structure their activities around timetables and calendars for administrative convenience.

On the other hand, ignoring time constraints for attaining learning outcomes though, is to ignore the reality of the real world - but what Killen (1998a) as well as Spady (1998) and Spady & Marshall (1991) are saying, is that teachers and learners should not be led to think that learning is over when the bell rings, but rather when they have mastered outcomes. The Curriculum Framework for General and Further Education and Training (Department of Education 1995a:39) also acknowledges the necessity for time limits when it states that for national recognition and affordability purposes, mutually agreed restrictions will, however, have to be placed on the **number of times** a learner may apply to be assessed against the same criteria for the same specific outcomes.

The contexts for specific outcomes to be mastered in a flexible time model, will be described in learning programmes. These will be developed at local, provincial or regional levels according to the prescribed requirements for each qualifications level on the NQF. The specific outcomes, which are underpinned by the critical outcomes, should serve as criteria for assessing the effectiveness of learning processes, learning programmes and the progress of learners (Department of Education, 1995a:30).

The above mentioned statement indicates that specific outcomes will not be functioning on their own, but will rely on two auxiliary structures namely assessment criteria and range statements.

(i) Assessment criteria

Assessment criteria are derived directly from specific outcomes and they provide evidence that a learner has achieved a specific outcome. The criteria give in broad terms an indication of the observable processes and products of learning which will serve as culminating demonstrations of a learner's achievement (Department of Education, 1997a:16).

The book *"Ways of seeing the National Qualifications Framework"* (HSRC, 1996:101) indicates that while specific outcomes are of the form "*learners will* + ***active verb****...*", assessment criteria should be written in the following format: *noun* + ***passive verb*** + *qualifier* (as indicator of level of complexity). An example from the Learning Area Natural Science is given for further clarification.

Table 2.11: An example of a specific outcome with assessment criteria

Specific outcome	Assessment criteria	
Use process skills to investigate phenomena related to the natural sciences.	Learners conduct explorative investigations in which:	
	1	Phenomena are identified.
	2	Investigative questions are formulated.
	3	A plan of action is formulated.
	4	Data are collected.
	5	Data are analysed, evaluated and interpreted.
	6	Findings are communicated.

(Department of Education, 1997a:146)

Since the assessment criteria are broadly formulated and do not in themselves provide sufficient details of what and how much learning proclaims an acceptable level of achievement of an outcome, range statements will fulfil this function. While the assessment criteria provide a framework for assessment, the **range statements** flesh out the "*substance of what assessment will be applied to*" (Department of Education, 1997a:16).

(ii) Range statements

Range statements provide a general guide to an assessor and a learner as to the scope, range of knowledge, degree of rigour and level of complexity of parameters of the achievement (HSRC, 1995:77). The salient verbs used for formulating assessment criteria are described in sufficient detail in range statements to assist in the planning of learning programmes and assessment strategies.

The range statements indicate the **content, processes** and **products**, but it is important to comprehend that it does not restrict learning to specific lists of knowledge items or activities which learners have to work through mechanically and behaviouristically. Although providing direction, range statements must be flexible and allow for multiple learning strategies, flexibility in choice of content and processes, as well as for a variety of assessment methods (Department of Education, 1997a:16-17).

While it is indeed possible that the assessment criteria for a specific outcome is the same for different grades and phases on NQF level 1, it is the **range statements** which will describe the **progressively increasing complexity** and **sophistication** as learners proceed to higher grades.

The critical outcomes will underpin all future curriculum development and learning in South Africa and must be used as the point of departure in the curriculum design process. For Curriculum 2005 the follow up actions, which involves the formulation of specific outcomes with their associated **range statements** and **assessment criteria,** have already been done on a national level for each of the eight Learning Areas. The Curriculum 2005 document, which is a national document, entails all the above mentioned curriculum elements. At the higher education level, the process could be quite different from the schooling level.

At the schooling level in the General Education and Training Band, actions following the formulation of national specific outcomes, assessment criteria and range statements, would be to develop **learning programmes.** Development of learning programmes will take place on a provincial or regional level. The Norms and Standards for Educators actually state that teachers should not only be able to interpret learning programmes, but that they should be capable of "designing original learning programmes" (Department of Education, 2000a:16). Learning programmes will consist of different outcomes selected from different areas of learning. The Curriculum 2005 document describes learning programmes as vehicles through which a curriculum will be implemented at various sites of learning such as schools.

Learning programmes, as opposed to subject syllabi, are not rigid, prescriptive and non-negotiable. When clustering various specific outcomes into a learning programme, integration and cross curricular learning is promoted. Learning programmes should rather be viewed as descriptive, integrative across Learning Areas, flexible guidelines which allow teachers to be innovative when planning learning experiences and setting up learning environments which would lead to the mastering of outcomes. Flexible learning programmes demand teachers who are competent and professional in their planning of educational endeavours and decision making.

One of the final design processes will be the development of performance indicators for each learning programme. Where range statements and assessment criteria are broad indicators of what learners need to demonstrate before they are seen as having achieved an outcome, performance indicators are more specific. They give the details of the content and contexts in which performance has to be demonstrated. Performance indicators will not only indicate whether an outcome has been achieved or not, but also the **level** of achievement.

2.4.3.4 Using of outcomes in the curriculum design process

(i) The subject-based curriculum development process

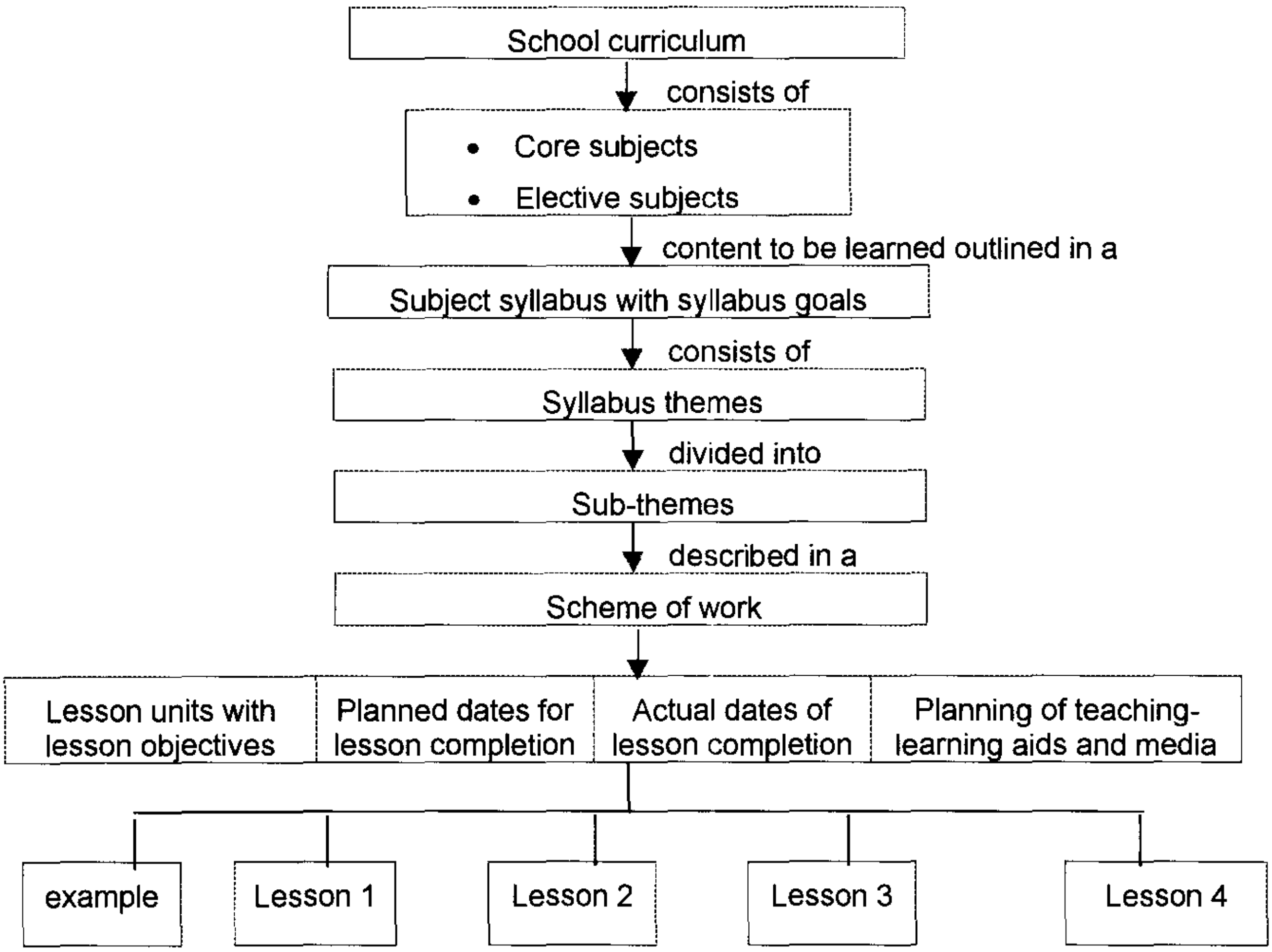
Traditionally subject-based curriculum designs were the most popular and widely used curriculum designs for many years. In the majority of schooling systems and also university courses, this remains the popular type of curriculum design. In this type of design the curriculum is developed around the essential knowledge and content that has developed in a specific subject area, also called the **substantive structure** of that subject.

The learning content to be dealt with in a subject area is then separated into syllabus themes which have to be mastered by learners over a fixed period of time, normally by the end of a school year. The teaching and learning process is consequently mainly driven by the end of the year exam, with the ultimate exam being the end of the school career exam in grade 12. Each syllabus theme is further divided into sub-themes which are normally described in more detail in a document called the "scheme of work". From the scheme of work teachers do their planning for the different lessons to be presented to learners (Fraser, 1996:80-82 and Olivier, 1998:32-33).

Since the teacher presents his/her planned lessons it is assumed that teachers together with text books are the major resources in the classrooms. In this type of design teachers assume the active role, while learners are predominantly receptive while listening to the lectures and lessons. This role which learners have to play tends to forster a passivity in learners and a reluctance to take responsibility for their own learning.

Curricula are rigidly planned in a top-down manner with little negotiation and input from stakeholders. The main function of the teacher is to implement the syllabus so as to achieve the preset goals and objectives within each syllabus theme. Figure 2.5 gives an illustration of the traditional subject-based curriculum design process.

Figure 2.5: Subject-based curriculum design process



The following paragraph will address processes regarding outcomes-based curriculum design.

(ii) The outcomes- based curriculum design process

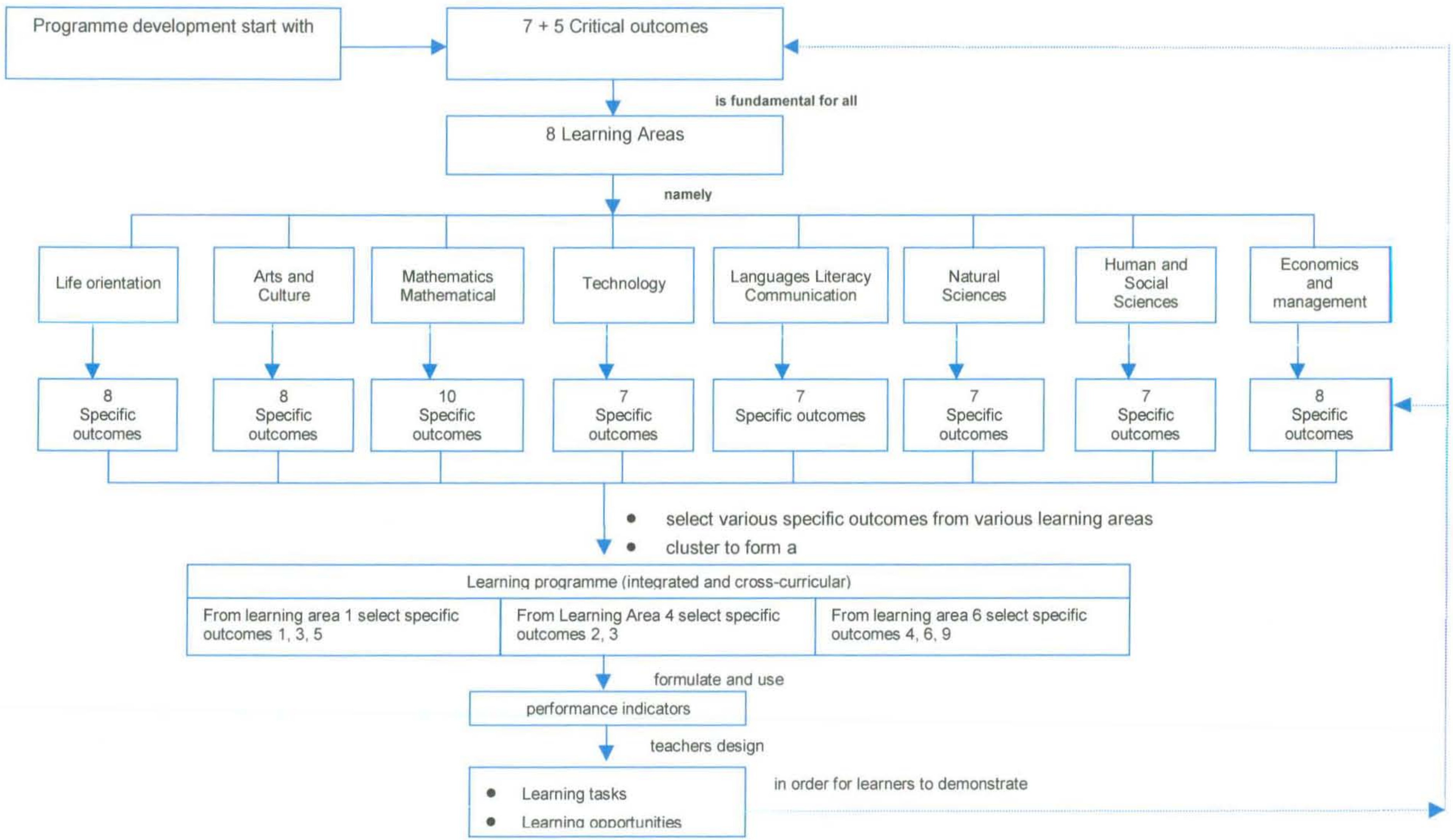
In this approach to curriculum or programme design, the process **starts with the outcome** (not the content) which is a clear picture of what learners must demonstrate at the end of their learning experiences. Only then are the "vehicles" identified by means of which the outcomes may be achieved. Vehicles to be selected might include appropriate content, resources, teaching-learning methodologies and assessment strategies.

For Curriculum 2005, the SAQA critical outcomes as well as the sixty six specific outcomes of the eight Learning Areas, have been provided by the National Department of Education. From these, the provinces, regions or teachers will design their own learning programmes starting with the outcomes. Since learning programmes intend to integrate learning across the Learning Areas, specific outcomes have to be clustered. Clustering is not a mechanical or permanent grouping of outcomes. The following principles are recommended when clustering outcomes (Department of Education, 1997a:17-18):

- The selection of specific outcomes must be done in such a way that the essential conceptual and thematic ambience of a learning area does not get lost.
- A learning programme should have a primary focus on one or more Learning Areas, but should also draw on specific outcomes, content, processes or context elements from other Learning Areas.
- Learning programmes should not follow a permanent formula for clustering outcomes. This should rather be a dynamic process to be followed by different material developers in different situations.

Once the learning programme has been developed, the performance indicators will be developed. They provide the details of the content and processes that learners should master, as well as the contexts in which the learners will engage. The following figure will illustrate the basic process of design:

Figure 2.6 The outcomes-based curriculum design process



The above-mentioned curriculum design process which includes clustering outcomes from various Learning Areas, mainly applies to Curriculum 2005 in the GET phase. For the FET and higher education bands, the process will not be exactly the same since the eight Learning Areas are not the major determinants across which integration has to take place. However, the fact remains that the design process also has to start at the SAQA critical outcomes, and exit level outcomes for particular qualifications.

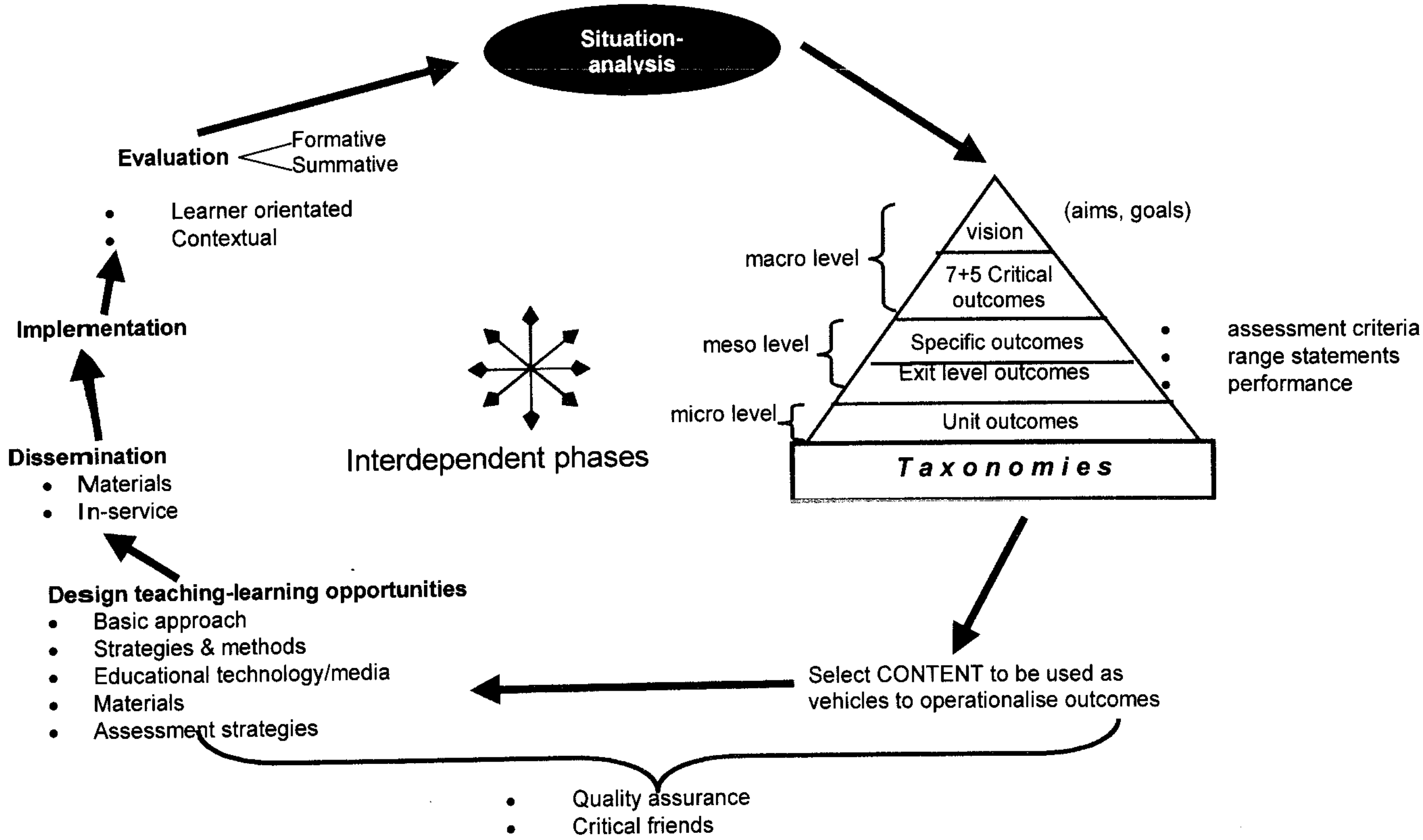
The outcomes-based design process also needs to be incorporated into the broader activity of curriculum development. Carl (1995:21) distinguishes between four major phases in curriculum development, namely design, dissemination, implementation and evaluation. Various curriculum development models have been suggested in the curriculum field which varied from the linear to cyclic models stressing the interactiveness of the different phases in development. The Tyler model (1958) is a linear model and is based on the well known Tyler rationale, which comprises four questions that introduce the elements of curriculum on which decisions should be taken. These are presented in Table 2.8.

Table 2.12: The relationship between Tyler's questions and elements of the curriculum definition

A LINEAR MODEL FOR CURRICULUM DEVELOPMENT BASED ON TYLER'S RATIONALE			
Tyler's questions		**Elements of curriculum definition**	
1	What educational purposes should the schools seek to attain?	1	Goals
2	What learning experiences can be provided that are likely to attain the purposes?	2	Content
3	How can these educational experiences be organised for effective teaching?	3	Materials and activities
4	How can effectiveness of learning experiences be evaluated?	4	Evaluation

The linear model was followed by cyclic curriculum development models which acknowledged the value of summative and formative feedback when replanning and improving curricula. Workers who contributed towards a generally acceptable cyclic curriculum model to mention a few, include Taba (1962), Wheeler (1976), Nicholls & Nicholls (1972), Saylor-Alexander (1981), Oliva (1992) Krüger (1980) and Kachelhoffer (1987).

A general curriculum development model which may be used for the current situation in South African development can be depicted as follows in Figure 2.7:


Situation-analysis
Evaluation
Formative
Summative
Learner orientated
Contextual
Implementation
Dissemination
Materials
In-service
Interdependent phases
Design teaching-learning opportunities
Basic approach
Strategies & methods
Educational technology/media
Materials
Assessment strategies
(aims, goals)
macro level
vision
7+5 Critical outcomes
meso level
Specific outcomes
Exit level outcomes
micro level
Unit outcomes
Taxonomies
assessment criteria
range statements
performance
Select CONTENT to be used as vehicles to operationalise outcomes
Quality assurance
Critical friends

All the outcomes-based curricula and learning programmes registered on the NQF will have to be managed. Although all the different South African curriculum management and development structures and bodies are not yet in place, the existing and envisaged initiatives will be explored and analysed in the following paragraphs.

2.5.4 Curriculum management and development structures envisaged for South Africa.

An encompassing National Qualifications Framework which has been developed, is currently in the process of being implemented and managed. The next section will look at the structures and bodies which are in the process of being established and who will have the daunting task to initiate and sustain tasks such as registering, co-ordinating, accrediting and quality assuring qualifications.

2.5.4.1 Future structures and institutions responsible for curriculum development and management in South Africa

In June 1994 the Ministers of Education and Labour established an Inter-Ministerial Working Group to establish an integrated approach to education and training and to prepare legislation for the creation of a National Qualifications Framework. The work went ahead and the NQF Bill was passed into law as the South African Qualifications Act on 4 October 1995 (SAQA, 1995:4). This brings the discussion to one of the paramount structures in future curriculum development and management – the South African Qualifications Authority – hereafter referred to as SAQA.

(i) The South African Qualifications Authority (SAQA)

SAQA has been conceptualised as comprising a board of between twenty-two and thirty members appointed by the Ministers of Education and Labour (HSRC, 1995:21). SAQA The members were nominated from a diverse group of role players including education, labour, universities, technikons, teachers' colleges, adult basic education and training, early childhood development, special education needs and the teaching profession (SAQA, 1997:4).

In terms of the SAQA Act (SAQA, 1995), SAQA has the following essential functions:

- SAQA must oversee the development of the NQF in consultation with bodies to be nominated by the Ministers of Education and Labour. It must formulate and publish policies and criteria both for the registration of bodies responsible for establishing educational standards, and for the accreditation of bodies responsible for monitoring and auditing achievements. Through the NQF, SAQA will ensure the facilitation of access to, mobility and progression within education, training and career paths.

- SAQA must oversee the implementation of the NQF. It must ensure the registration, accreditation and assignment of functions to the registration and accreditation bodies, as well as the registration of national standards and qualifications.

- SAQA will advise the Ministers of Education and Labour.

- SAQA must consult with all affected role players. SAQA is obliged to comply with the rights and powers of bodies in terms of the Constitution and Acts of Parliament (HSRC, 1995:21 and SAQA, 1997:5).

- SAQA is also responsible for the development of level descriptors for the 8 main levels of the NQF and the sub-levels in the General Education and Training band. Level descriptors describe briefly the expected level of competence of learners at a specific level in relation to certain critical outcomes. Level descriptors will be developed in co-operation with the National Department of Education (to be called the National Institute of Lifelong Learning Development), the envisaged Higher Education and Training Council and other role players (Department of Education, 1996a:50). The SAQA Bulletin (1997:7) states that compilers of qualifications must ensure that all the critical outcomes adopted by SAQA, have been addressed appropriately at the level concerned for registration on the NQF. If it is not the case, compilers of qualification will be required to address the exclusion to the satisfaction of SAQA before it may be considered for registration.

Various bodies will assist SAQA to fulfil the various roles and functions described above.

(ii) National Standards Bodies (NSBs), Standards Generating Bodies (SGBs) and

Education and Training Quality Assurance Bodies (ETQAs)

National Standards Bodies (NSBs) are established by SAQA, with one NSB representing each of the 12 organising fields. NSBs will include no more than 36 members from six stakeholder representative categories: business, labour, state, providers of education, critical interest groups and learners (communities) (SAQA, 1997:11). The NSBs will oversee the setting of standards in the various fields of learning. The work of the NSBs was launched on 21 and 22 October 1999 at the Old World Trade Centre by the Deputy Minister of Education (SAQA, 1999a:1).

Standards Generating Bodies (SGBs) are bodies which are registered in terms of section 5(1)(a)(ii) of the South African Qualifications Authority Act of 1995 (SAQA, 1995). They are responsible to for establishing education and training standards or qualifications. In other words, standards, consisting of specific outcomes, assessment criteria and range statements, are developed for the different levels and sub-levels by Standards Generating Bodies (SGBs) (SAQA, 1998:2). These bodies will take their authority from their relationship to the NSB in the organising field to which they belong. Unit standards developed by SGBs will be recommended via the NSB to SAQA for approval and registration on the NQF.

The SGBs will comprise of **practitioners** in a specific area or organising field, at least one member whose brief it is to ensure progression and continuity from the previous level up to the level above, and one member whose brief it is to ensure portability. Portability implies maximum transferability across a level between different providers of education and career paths (Department of Education, 1996a:51).

Functions of SGBs will include the following (SAQA, 1997:12):

- SGBs are responsible for the generation and recommendation of unit standards and qualifications to the NSBs.
- SGBs will update and review existing unit standards.
- In relation with the functions of SGBs, the primary functions of the NSBs will entail the following (SAQA, 1997:12):

- Recommend a framework of sub-fields within the 12 organising fields to be used as a guide for the establishment of SGBs.

- Ensure that the work of a SGB complies with the SAQA requirements for development and registration of unit standards and qualifications.

- Recommend the registration of unit standards on the NQF to SAQA.

- Define the requirements and mechanisms of moderation to be applied across Education and Training Quality Assurance bodies (ETQAs).

The Education and Training Quality Assurance bodies (ETQAs) will also be accredited by SAQA with national stakeholder representation and will, to ensure integrity, not be a direct provider of education. In the case of the General and Further Education and Training band, the ETQA is likely to be associated to the provincial Education Department, but will include other stakeholders to ensure integrity so that the providers do not monitor their own provision alone (Department of Education, 1996a:51).

Functions of ETQAs are the following (SAQA, 1997:12):

- Promote quality amongst all the different providers of education and accredit them in terms of quality management.

- Register prospective assessors, evaluate assessment, certificate learners, maintain an acceptable database and submit reports and feedback to SAQA.

- Monitor and moderate the work done be education providers and undertake quality systems audits.

(iii) Who will be responsible for the development of curriculum frameworks and learning programmes?

A curriculum framework is a common, overall framework providing a philosophical foundation for the development of curricula. Curriculum frameworks will ensure that learning programmes developed are balanced, reflect education policy principles and goals, and that they promote nationally consistent and internationally acceptable standards.

The Curriculum Framework outlines the principles guiding curriculum development, the organisation of the General and Further Education and Training bands, as well as the Learning Areas to be addressed. In addition to a Curriculum Framework it will be necessary to draw up a separate detailed framework outlining the new modular structure and rules of combination for qualifications in the Further Education and Training band. This detailed framework will also have to provide for the differing needs of different learners in the General Education and Training band, such as Adult Basic Education and Training (ABET), learners with special needs, pre-school and compulsory schooling (Department of Education, 1996a:52).

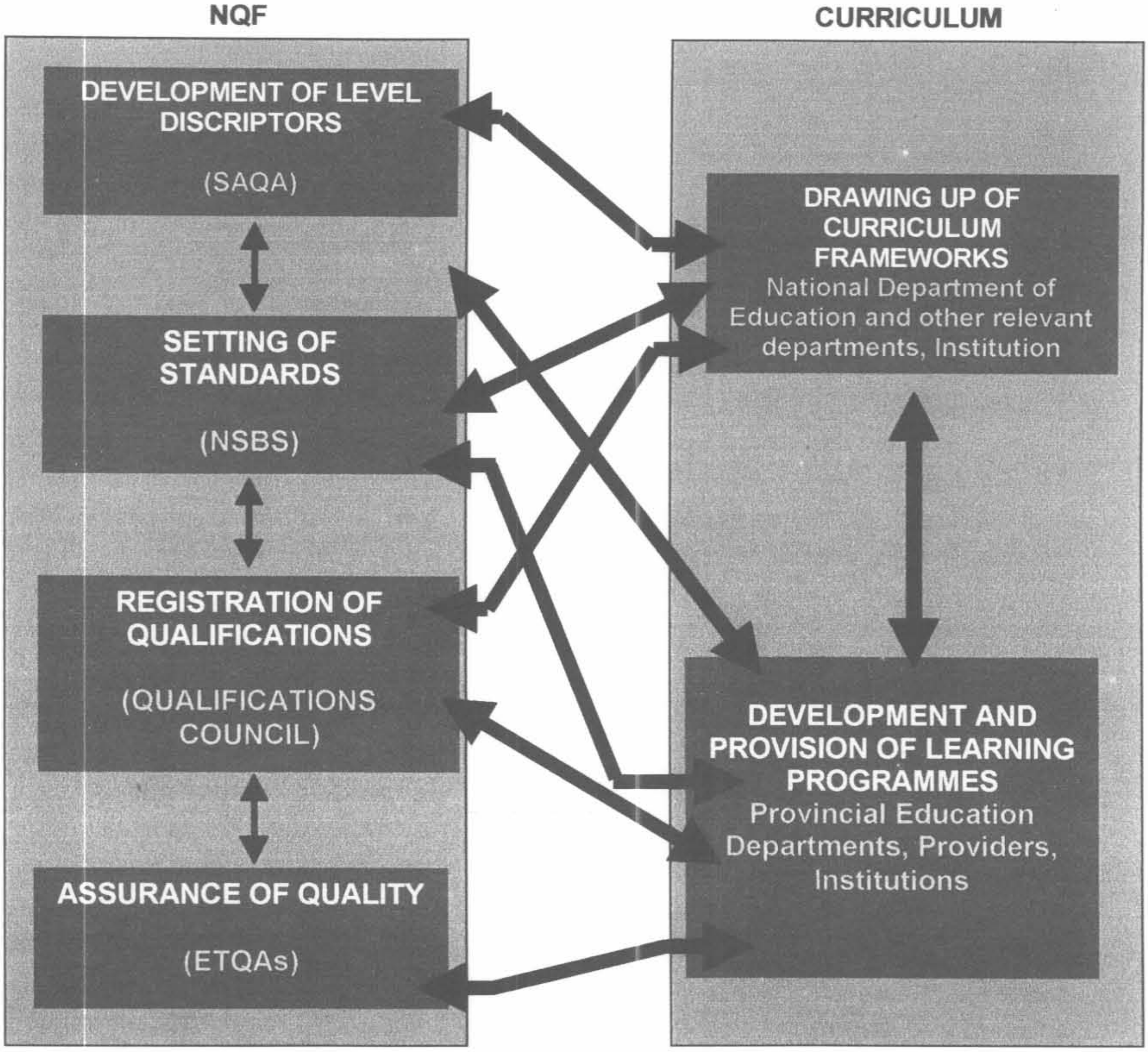
The national Department of Education (National Institution for Lifelong Learning Development), in consultation with Provincial Departments (Provincial Institutes for Lifelong Learning Development) and other relevant role players will be responsible for the drawing up of a **National Curriculum Framework.** Relevant role players to be consulted are industry, especially those that are vocationally orientated and relate to particular economic sectors, higher education, learners, educators and trainers. Central to a National Curriculum Framework is the development of guidelines for potential clustering of unit standards into a relevant learning programme, conducting assessment and providing typical examples of teaching and learning materials (Department of Education, 1997d:56 and Department of Education, 2000b:11-12).

Curricula and learning programmes emanating from the National Curriculum Framework will be outcomes-based, but **will not prescribe in detail the content** which will contextualise learning (Department of Education, 1996a:52). Learning programmes will be developed at the level of education provision. Learning Area Committees (on which the provinces will be represented) are responsible for the actual designing of learning programmes (Niebuhr, 1997:97). In adult basic education and early childhood development a number of public, private, national, provincial and local designers may provide their own learning programmes, while in formal schooling at General Education and Training level, the provision will be at provincial and local levels. It is envisaged that in formal schooling, approximately 80% of the timetable might include provincial competence, while 20% might be left unassigned to allow freedom and innovation on regional, local and school levels ((Department of Education, 1996a:52).

In the Further Education and Training band a very wide variety of provision, covering a range of contexts, also exist. All private providers will be guided and governed by the same processes as central providers if their credits and qualifications are to be Registered on the NQF. Learning programmes are developed on an inter-provincial basis and these learning programmes will eventually be taken up as provincial curriculum statements (Department of Education, 1997a:18 and Department of Education, 1996a:53).

The interactive relationships between the curriculum development and management functions on the one hand and the relevant bodies performing the functions on the other, might be represented as follows in Figure 2.8:

Figure 2.8 Interactive relationships between curriculum development functions and relevant bodies in service of the NQF



(Department of Education, 1996a:50)

2.5.5 Concluding comments on an outcomes-based educational approach

The debate of whether to implement an outcomes-based approach or not, is an extensive one, because every approach or philosophy has its advantages and limitations for a particular given situation. South Africa has mainly opted for transformational outcomes-based education because of the broader purpose to emphasise equity, access, redress, quality assurance and accountability in terms of economic and social development (Cockburn, 1997) on the one hand. On the other, to develop a curriculum that will provide the platform for knowledge, skills and values for innovation and growth for the 21st Century and for cultural creativity and tolerance for the African Renaissance (Executive Summary of Curriculum 2005, 2000:2).

Throughout the previous two chapters, a rational for using OBE and the advantages of using this approach to reform education and training in South Africa, has been discussed. There are also critics who highlight what they believe are the limitations of OBE. Some critics contend that it is primarily an approach used for social re-engineering. They say that if a ruling government prescribes the outcomes, leaving no affordable alternative forms of schooling for parents to choose from, education can become indoctrination. They warn that government can use education to achieve political aims of controlling its citizens (Schlafly, 1993). Dlugosh, Walter, Anderson & Simmons (1995:179) write that *"critics support the notion that OBE is a dangerous experiment in social engineering, that it teaches a set of values some parents do not embrace, that it 'dumbs down' academics, and that it is prohibitive in terms of overall cost to taxpayers".*

It is also feared that learners may become confident illiterates, due to the strong focus on co-operative work and a lack of specification of core academics content. In a diverse, pluralistic country such as South Africa, it is not always easy to achieve consensus amongst all role players. A democratic country, which South Africa is intended to be, should leave enough alternatives of private schooling for parents who fear that government will not provide the values they believe in (Van der Horst & McDonald, 1997:16).

Furthermore, critics argue that to implement OBE in a developing country like South Africa, is very expensive and that there are other very basic needs in terms of housing and health, which have to be addressed first. This of cause is a debatable issue, because general education is also a basic need and right of all learners, which can contribute to solving problems associated with basic health for example. Implementing any new educational initiative is expensive. Thousands of teachers have to be retrained, learning materials and resources have to be developed and distributed, which is a very expensive exercise. The in-service training will be a mammoth venture, but is of the utmost importance for a sophisticated approach such as OBE to succeed. In-service training will not only have to address the understanding, new language and labels, methodologies and assessment of an OBE approach, but as described in Chapter 1, also the low levels of expertise of many teachers in specific learning areas such as mathematics and science. Having taken into account the all encompassing impact of OBE, as well as the low levels of competence of many teachers in South Africa, policymakers driving the reform for their own agendas, should not ignore the voices of teachers and specialists in the field of education. The stakeholders who actually work in the field of education on a day-to-day basis, call for a less feverish rushed and enforced implementation of the new curriculum in a particular grade, for all schools, in the same year. The principle of readiness should guide the implementation. Schools, school leadership and teachers should be given enough time and support from administrators to get themselves ready and organised for taking on the challenge of implementing a new curriculum (Technology 2005 Evaluation, 1999:165).

Another concern regarding OBE, are standards. Critics stated that the OBE principle of "success for all learners" meant that standards had to be lowered if both the smart and not so smart had to be successful. Spady (1998:52) reacted to this by saying that critics viewed standards and success as opposites in learning. He says that critics reason that one has to lower standards to get more success, or lower the rate of success if you intend raising standards. Critics did not realise that an alternative existed which Spady (1998:52) calls the "*expandable commodity/win-win*" elevator of achievement.

Other critics fear that standards will be lowered which will enhance mediocrity, because of the focus on the achievement of minimum criteria (Dlugosh, Walter, Anderson & Simmons , 1995:179). It is feared that gifted learners will be held back, until all the learners have achieved the minimum criterion. Spady (1998:53) points out that the commitment to create successful learning for all learners did not assume that all learners would end up with equal "minimums" and no more. He says that OBE was committed to raising expectations for all learners – including the smart – so that all learners could learn better and more. That had the implication that schools had to clearly state the levels of achievement and document how far learners had progressed in reaching the levels. Glass (1978:251) also attacks the advocates of minimal competence for two reasons, namely that the model has no foundation in psychology and that judges disagree on the arbitrariness of the values when minimal competence has to be identified. She argues that the language of performance is pseudo quantification, a meaningless application of numbers to a question not prepared for quantitative analysis. To avoid this from happening the perceived minimum standards must not be set too low. Secondly, to challenge learners to maximise their potential, teachers will have to be skilled in the designing of learning opportunities for different learner abilities and the assessment of learners. Peters (1966) makes a persuasive argument that "*worthwhile activities have their own built-in standards of excellence, and therefore they can be evaluated according to the standards inherent in them rather than according to some end or outcome*" (in McKernan, 1994:2).

Outcomes-based education with its *behaviouristic history* is also the concern of some critics. The initiative of an outcomes-based approach in the South African context has it roots in the industrial, labour and training spheres and like other education approaches it may be judged in terms of other traditional scientific approaches where the focus is on the measurable, predictable, causal and thus also on the manageable (behaviourism) dimensions of performance and behaviour. Melton (1996:416) mentions that the fundamental principles of an outcomes-based approach and behaviourism have elements in common. This constitutes one of the points of criticism of an outcomes-based approach, in that predetermined outcomes, if too narrowly defined, might be positivistic and prescriptive in nature (Department of Education, 1997d:51). Jansen (1998:326) also warns that detailing specific outcomes will become a reminiscent of the 1970s "objectives movement" where the outcomes became the focus of over-specification. It means that hundreds of little objectives were being defined in an attempt to be precise about what was meant to be assessed. The teachers (both qualified and unqualified) then have to teach towards a minutiae of outcomes or objectives which can backwash into South African schools and classrooms as a technical, mechanical model of behaviourism.

The South African Curriculum Framework for General and Further Education and Training (Department of Education, 1995:29) warns about the disadvantages involved in taking a too narrow view of outcomes-based education. They (Department of Education, 1995:29-30) contend that

> *if correctly applied, this shift in focus [from inputs to outputs] would encourage the development of flexible, relevant curricula. If applied too narrowly, the shift*

could emasculate the profound meaning and power of effective education and not do justice to the full humanity of the learner. In stressing what is quantitatively measurable, rather than the more complex and subtle qualitative outcomes of learning and teaching, there is a danger of ignoring long term goals which are most valuable.

The way in which outcomes are **selected** and **finally formulated** is therefore crucial to avoid narrowness and pre-scriptiveness. The critical outcomes and the specific outcomes in Curriculum 2005 are NOT narrowly defined, which allows for the flexibility referred to in the above quotation. The format adopted for a unit standard by the South African Quality Authority has attempted to marry both the generic and Learning Area specific outcomes in such a manner to avoid narrow and positivistic outcomes (Department of Education, 1997d:51).

This section has briefly reflected on some opinions and warnings from critics of OBE. Policy makers and implementers should take cognisance of valid warnings. Furthermore, they should seek sound continuous research feedback on the implementation and impact of OBE. Currently, the Minister of Education, Prof Kadar Asmal is setting in motion a national formative evaluation process. He achieved this through the appointment of the Curriculum 2005 Review Committee on 8 February 2000.

2.6 Summary

Chapter 2 has investigated OBE as a curriculum reform approach to education and training, against the background of educational philosophies which have impacted on curriculum work over the ages. A clear picture has been sketched of the transformational OBE environment and systems in which all pre- and in-service teachers will have to work as curriculum stakeholders and implementers. Any pre-service educator training programme will have to prepare and empower the future teachers for the mammoth task of making a paradigm shift in their own minds and everyday practice.

The next chapter will look in more detail into the philosophical characteristics of OBE. It will particularly focus on the implications of the OBE philosophy on best classroom practice in terms of teaching strategies and methods which will operationalise OBE. It will also look at the new Learning Area in Curriculum 2005, namely technology education and its nature and structure in relation to appropriate strategies for facilitating learning from an OBE approach. The field of problem-based leaming will be explored and related to the demands of both a new OBE paradigm and technology education.

CHAPTER 3

Investigating problem-based learning as a strategy to operationalise outcomes-based education in the training of pre-service technology teachers: Designing an OBE-PBL model

3.1 Introduction

In Chapter 2 the outcomes-based paradigm which lies at the heart of educational transformation in South Africa, was described. Where the previous chapter focused on the philosophical and systems dimensions of the paradigm, Chapter 3 will focus on a third dimension. This dimension comprises the challenge of translating OBE into practice. OBE in practice has major implications for training teachers, because it implies that teachers need to rethink the way they do their day-to-day planning, teaching and assessment. Teacher trainers therefore, need to rethink their training practices to align them with the prevailing OBE paradigm.

In this regard, problem-based learning (PBL), will become a major focus area for this chapter for two reasons:

- PBL has the potential as a teaching or training strategy to operationalise OBE in practice.
- PBL and the nature of technology education are inextricably linked and similar. Therefore, the potential of PBL for the training of technology teachers will be explored.

Each of the two aforementioned reasons, acting as driving forces for implementing PBL, will be discussed in more detail in this chapter. The final outcome of this literature-based chapter will be the construction of a meta-curriculum model which can be implemented when planning PBL training programmes for prospective pre-service technology teachers.

3.2 Outcomes-based education: From theory to practice

To be able to explore implementation of the OBE philosophy in practice, it is necessary to briefly be reminded of the purpose and premises of OBE on a praxis level.

3.2.1 Purposes and premises of OBE to be operationalised in practice.

The fundamental belief of OBE is that all learners can be successful in their learning so that they can eventually become successful in performing complex real life roles. For South Africa, these complex real life roles are contained in the seven plus five SAQA critical outcomes. When these outcomes are successfully internalised and demonstrated learners are believed to have the basic competencies which enable them to become lifelong learners and productive members of society. Therefore, the educational system, from the macro managerial level to the micro level in classrooms, should be structured in such a way that learners can indeed be successful (Spady, 1994b:9). This belief is based on the optimistic view of learner potential explicated in the following premises (Spady, 1994b:9-10):

- **All learners can learn, but not at the same pace and in the same way:** This premise acknowledges the different rates of learning and learning styles. It is important to note that barriers such as different learning rates and styles are not viewed as obstacles to learning, but as realities which have to be designed for in practice.
- **Successful learning promotes even more successful learning**: This premise suggests that learning success may be enhanced when learners have strong foundations of cognitive and psychological prior learning success.
- **Institutions such as schools and universities control the conditions that directly affect successful learning**: Institutions can restructure themselves, their courses, time schedules, methodologies and strategies for teaching, learning and assessment differently from in the past, to encourage and support all learners to be successful in attaining the immediate and real life performance competencies.

To put the OBE purpose and premises in action, teaching and training practice have to reflect very specific characteristics which differ from the traditional paradigm. Some of the characteristics of an OBE practice can be outlined as follows:

- ***Learning opportunities are learner-centred and not content or teacher-centred***

It is often believed that there are two broad approaches to teaching, namely teacher and learner-centred approaches. Killen (1998b:v) contends that, in some way, it is an unfortunate set of labels, because learning, and therefore learners, should be at the centre of learning. Never the less, "*these labels certainly convey the idea that in some approaches to teaching the teacher plays a more direct role than in other approaches*" (Killen, 1998b:v). Learner-centredness on the other hand, places the focus on the learner. This characteristic must be interpreted in its broadest sense. Firstly, it means that learners are not merely receivers of the curriculum, but participants in it. In learner-centred settings, learners are actively constructing meaning while accessing and utilising information in a variety of ways (Windschitl, 1999:752). They are not merely passively absorbing information by means of listening to what teachers have to say. This is in agreement with constructivistic theory where a learner constructs new knowledge based on prior learning (Hewson & Hewson, 1983:732; Novak & Gowin, 1984:xiii and Redish, 1994:1-21).

In traditional curricula, which are content-centred, the covering the content of the core curriculum was the purpose for all learning as explained in the discussion of the educational philosophies and their effect on curriculum development, teaching and learning in Chapter 2 Section 2.3. Whatever content was transmitted by the teacher mainly had to be memorised by learners and reproduced in assessment, which tended to encourage rote learning. Rote learning of content is also promoted when learning takes place outside a particular context that is meaningful for a learner. Often in the traditional paradigm where learners were expected to do something, the teachers believed that they had to demonstrate first, which implied that the learners had to imitate the teachers (Slabbert, 1996:30 and Boshuizen, 1994:5-6). Consequently, learners remained dependent on a teacher and did not necessarily become empowered as lifelong learners.

Learner-centredness entails more than using strategies which involve learners actively in their learning processes. It may also mean that the development of the whole learner and the society in which the learner has to function, is implied. While learner-centredness in OBE implies the holistic development of a learner, it also implies that every learner achieves the set of outcomes. Malcolm (1999:120) says that Curriculum 2005 commends processes as well as specific outcomes in its definition of quality education and by doing so "*it acknowledges covert learning about individuals, societies, human interactions and moral principals as outcomes of schooling*". In terms of science education for example, it means that instead of asking "what science should learners know", we should also ask "how will the science contribute to a learner's and a nation's life?". The point made here is that learner-centred curricula also acknowledges the learning and generic needs of learners. It seems an appropriate thing to do since a large-scale survey of schools learners in the United Kingdom for example reported that 20-30% were bored and disappointed with their school experiences, 10-15% were openly hostile and 5-10% were frequent truants (Malcolm, 1999:118). These figures show that about half of the learners disconnected themselves from their classrooms. This reality seems to imply that learner-centredness should attempt to align learner and teacher agendas. Advocates for learner-centredness also promote the idea that learners should have a say in the setting and interpretation of outcomes which they have to demonstrate, or else they may not value the official prescribed outcomes which might result in a percentage of the learner generation getting lost. This particular notion of learner-centredness is compatible with the mission of the humanistic curriculum which was discussed in Section 2.3.3.

The above mentioned interpretations of learner-centredness have one principle in common if learning is to be efficient and effective. This principle is responsibility on the side of learners and teachers. This important OBE principle will be elaborated in the next paragraph.

- ***Learners take responsibility for their own learning***

In OBE, learners are expected to take more responsibility for their learning than might be the case in traditional teacher-centred approaches. Learning opportunities should be designed so that the teacher allows learners to be accountable for their own learning by being actively involved in the learning process. By doing this, learners are empowered to become lifelong learners. However, this characteristic if often misinterpreted by teachers in that they perceive their role to be a laissez-faire one with reduced responsibility. This cannot be further removed from the truth. It is the teacher's responsibility to promote responsibility in learners. A teacher is ultimately accountable for his/her learners' quality of learning – that is their core business. Killen (1998b:v) explains that, when learner-centred approaches such as co-operative learning are used, the teacher still sets the agenda, but he/she has much less direct control over what and how learners learn. This is in line with the third OBE premise posed by Spady (1994b) which states that teachers and institutions are responsible for creating the conditions for learners to be successful.

- ***OBE is characterised by the principle of expanded opportunity***

This principle is inextricably linked with the belief of OBE which states that all learners can be successful. In order to provide learners with expanded opportunities which can help them to become successful, teachers must take a broad view of intelligence and capacity to learn. Basically the principle of expanded opportunity requires educators to give learners more than one chance for learning and demonstration of that learning, since not all learners learn in the same way at the same pace (Spady, 1994b:12). This means that, for example, time must be used as a flexible resource and that learners who did not understand a concept fully when the bell rang at the end of a period, should be provided with additional learning opportunities. This, however, does not mean that learners can take as long as they want to learn something or to complete their work. Learners must be responsible and accountable to meet the conditions which will "earn" them the expanded opportunities (Spady, 1994b:12).

Expanded opportunities can also be designed for in teaching and learning strategies and methods. In Chapter 2 Section 2.3.5 it was seen that post-modern classrooms are typified by pluralism and diversity in terms of cultures, world views, learning and teaching styles, learner capabilities, intelligence and interests. Much research has already been done on how to accommodate the variety of learning and teaching styles in classrooms (Dunn, 1984; Hyman & Rosoff, 1984 and Smith & Renzulli, 1986).

Gardner (1993:6) voiced his dissatisfaction with the unitary concept of intelligence with his vision of intelligence which is

> *... a radically different view of the mind, and one that yields a very different view of school. It is a pluralistic view of mind, recognizing many different and discrete facets of cognition.*

His vision and definition is in accordance with post-modern curriculum philosophy. He defines intelligence as follows (Gardner, 1993:7):

> *Intelligence is the ability to solve problems or to fashion products that are valued in one or more cultural or community settings.*

Gardner's (1993) framework for multiple intelligences distinguishes seven categories of which some are associated with the left and some with the right hemisphere of the brain (Jensen, 1994). The intelligences mainly associated with the logical-analytical left hemisphere of the brain are the following (Jensen, 1994:126-138 and Slabbert, 1996:162-163):

- **Mathematical-logical:** The ability to solve problems, do mathematics, troubleshoot, understand order and program.
- **Verbal-linguistic intelligence**: It constitutes the ability to perceive, interpret and produce language, speak, argue and debate. It is essentially verbal in nature.

The following intelligences are mainly associated with the right sphere of the brain:

- **Spatial:** This intelligence deals with one's relationships to objects and others. A mental model is constructed of a spatial world which is used to manoeuvre and operate in spatial reality, such as sport, dance, parallel parking, driving a truck and ice-skating.
- **Musical-rhythmic intelligence**: It deals with the ability to perceive, appreciate, make and compose music.
- **Bodily-kinesthetic intelligence:** It is the ability of control over bodily movement to solve problems. Bodily movement is localised in the motor cortex of the brain, where each hemisphere controls the movements on the contra-lateral side. It involves sport, exercise, mime, drama and acting.
- **Interpersonal intelligence:** It is the ability to relate with others and co-operate with

other people. It involves social skills, empathy, friendships and cultural bonding.

- **Intrapersonal intelligence:** It involves a relationship with the inner self. Meta-learning and its associated strategies such as planning, monitoring, evaluation, is thus the central determinant of intelligence (Sternberg, 1981). Intrapersonal intelligence reflects the characteristics of meta-learning which is reflection, introspection, self-assessment, vision and knowing weaknesses and strengths.

Another type of intelligence which is not cognitively based but which focuses on emotions, is called emotional intelligence (Goleman, 1995). The five domains of intelligence are knowing one's emotions, managing emotions, motivating oneself, recognising emotions in others and handling relationships. This type of intelligence becomes important for some of the critical outcomes which deal with collaboration in a team, handling conflict, group work, co-operative learning and managing oneself. Alongside Gardner (1993) and Goleman (1995), De Beauport (1996:xxvii) also redefined and reorganised categories of intelligence. She distinguishes between mental, emotional and behaviourial intelligence, with the following sub-categories of intelligences classified under each of the three main types:

The mental intelligences

- *Rational intelligence*: the process by which we perceive information through sequential connections, involving primarily the use of reason, logic, cause and effect.
- *Associative intelligence*: the process that allows us to perceive information through multiple connections, involving primarily the use of juxtaposition, association, and relationship.
- *Spatial intelligence*: the process of perceiving information at a deeper level, synthesized sometimes into images, sometimes into sounds, or other combinations received from the senses and deeper brain systems.
- *Intuitive intelligence*: direct knowledge without the use of reason; knowing from within.

The emotional intelligences

- *Affectional intelligence*: the process of being affected by something or someone; developing the ability of closeness with a person, place, object, idea, or situation.

- *Mood intelligence*: the ability to enter into, hold with and shift from any mood, whether the experience feels painful or pleasurable.

- *Motivational intelligence*: being aware of our desires and knowing what excites us and moves us the most; the ability to guide our life in relation to what we love.

The behaviourial intelligences

- *Basic intelligence*: the ability to move ourselves toward or away from; being able to imitate or inhibit anything or anyone on behalf of our own life or the lives of others

- *Pattern intelligence*: the ability to know the patterns governing our behaviour and being able to alter them when necessary.

- *Parameter intelligence*: the ability to recognize, extend, or transform the rhythms, routines, and rituals of our life.

These alternative conceptualisations of intelligence types provide teachers with more insight into learner interests and capabilities which need to be planned for in instructional design in terms of expanded opportunities which can enhance learner success and excellence.

- ***The role of the teacher has changed from that of teacher to that of facilitator of learning***

A teacher is no longer perceived as a transmitter of knowledge (Slabbert, 1996:30) and can therefore no longer only use teaching strategies such as direct instruction, deductive or expository teaching which are typified by a lecture format used for whole class teaching (Killen, 1998a:15 and Ornstein & Hunkins, 1993:44). Piaget (Armstrong, 1991:44) gave his impression of a teacher being more than an instructor when he said that a teacher's *"role should rather be that of a mentor stimulating initiative and research"*. Heidegger (Armstrong, 1991:48) explicitly describes facilitating learning when he says:

The real teacher, in fact, lets nothing else be learnt than – learning. His conduct, *therefore, often produces the impression that we properly learn nothing from him.*

Teachers are now designers, implementers and managers of learner-centred learning opportunities, earning them the name of facilitators of learning. It is important to note that teachers are not merely facilitators. Since their core business is to optimise learning for each learner, they are facilitators of learning. Whenever the term 'facilitator' is used in this work, it is meant to refer to facilitator of learning. This does not mean, however, that facilitators will never use the strategy of direct instruction again. A professional facilitator will be able to decide on the best teaching strategies, depending on the nature and purpose of a particular learning opportunity. If a section of a learning opportunity will be best served through direct whole class instruction, the professional facilitator will make the best decision and teach the class accordingly. As a facilitator of learning, a teacher will also give intellectual and emotional support to learners in their active search for and construction of knowledge. In a less structured learning environment, such as problem-based learning for example, the facilitator of learning might need to support learners more regularly on an emotional level. Learning in problem-based environments might not always be of the calm, rational kind but emotionally charged when learners experience failure and frustration (Claxton, 1999:26).

A teacher is also no longer the only authoritarian source of knowledge, but one of the many information resources available to learners (Department of Education, 2000a:15-16). They are more than instructors only. They are collaborators, mentors and coaches who should sustain an environment that promotes meaningful, successful learning (Seifert & Simmons, 1997:90). Pike (1989:67) elaborates on the actions to be demonstrated and roles to be played by facilitators of learning when he addressed a group of trainers in the following manner:

> *Our purpose as trainers is not primarily to counsel, interpret, instruct, or in any way lead people to believe that we are to supply the answers to their questions. Instead we should let the seminar, the instruments, the projects, the case studies, and the other materials serve as the resources that the participants can draw on to solve their problems and develop appropriate plans of action.*

> *The approach I recommend limits lectures and maximizes discovery and participation. Sometimes it may not seem that you are needed, but you are – often in ways that participants don't perceive. Ideally, you're the best kind of teacher - a facilitator of insight, change and growth who teaches that answers come from within.*

Killen (1998b:75-76) also describes various roles which a facilitator of learning will need to adopt, especially when learners are engaged in co-operative learning. When a group is not making adequate progress the role of *tutor* may be most appropriate. A tutor may provide additional information, explain things or simply answer questions. The role of *consultant* may be adopted especially when a group is unsure if their conclusions are valid due to a possible lack of knowledge of a subject. In the role of *discussion leader*, a facilitator might need to intervene to temporarily take on the leadership of a particular group by asking questions or making suggestions. This might happen when a group leader is temporarily unable to keep the group focused and productive. The role of *counsellor* is appropriate when group dynamics or conflict is interfering with the group's progress. The counsellor must help learners to focus on the task again and to understand group dynamics.

More roles of teachers as facilitators in the OBE paradigm, as presented in the Norms and Standards for Teacher Education (Department of Education, 2000a), will be attended to after this sub-section.

- ***OBE practice is characterised by collaborative and co-operative learning***

Midkiff (1990:13) identifies three situations in which learners may find themselves working in a classroom setup. They can *compete* with one another to see who is the best and according to Taylor (1991:245) traditional classrooms are characterised by competition. They can work *individually*, not needing one another or sharing ideas. They can *work together* in a way where each learner has interest in their own work, but also in that of their fellow learners. Sometimes, depending on the outcome to be demonstrated by the learner, it will be necessary to work with a combination of these situations.

In real life contexts, problems are seldom solved in isolation, because of the holistic and inter-related nature of real problems (Gorman, Plucker & Callahan, 1998:531 and Seifert & Simmons, 1997:91). It must be noted that although the OBE South African documentation suggests the use of team, group and co-operative learning (Department of Education, 1997b:38 and Department of Education, 1995a:32), is does not mean that learners should be forced to do all learning in this way. Killen (1998a:16) puts the focus on co-operative and group strategies in perspective when he explicates that "*co-operative learning should be used as part of any OBE system, but it is by no means the only teaching/learning strategy that should be employed*".

One of the aims of the General and Further Education and Training Bands supports this interpretation of implementing co-operative strategies in the following manner:

> *Develop in all learners the ability to work independently as well as co-operatively (as member of a team/group/organisation/community) when and where acquired.*

It must be stated at this point of the discussion that collaboration can be enhanced by using either learners working as *pairs, groups or co-operative learning* groups. These methods are not the same and a facilitator will have to know the differences when planning a learning opportunity with a certain outcome in mind. Davidson (Davidson & O'Leary, 1990:1) comments as follows on group work and co-operative learning groups:

> *Co-operative learning involves more than just putting students together in small groups and giving them a task. It also involves careful attention and thought to various aspects of the group process.*

It seems then that very specific *criteria* have to be met before the purpose of co-operative learning will be realised. The criteria for co-operative learning to qualify as co-operative learning, will briefly be presented (Johnson & Johnson, 1990:12 and Johnson, Johnson & Holubec, 1988:8-9):

- **Positive interdependence:** This means that a problem must be designed in such a way that each individual's contribution in the group is of the utmost importance to meet the final demands of the task. Successful completion of individual tasks which are part of the overarching group task, is a premise for success. It implies that individual learners depend on one another to achieve success.

- **Individual accountability:** In the overarching problem or learning task design, a task for which the individual learner is responsible, should be built in. To be successful as a co-operative group however, each individual learner in the group should have complete knowledge in terms of the what and how of *other individuals'* tasks in the group (Slabbert, 1996:237). The implication of this is that learners are compelled to question and teach one another on the what and how of their individual tasks (Johnson & Johnson, 1990:103-106 and Sharan & Sharan, 1987:22).

To enforce this accountability, any learner in the group can be nominated to score the work of the whole group. This criterion avoids learners becoming non-participative in the learning process. It was often the concern of teachers that learners who were not verbally participative in a group, did not learn in the process. However, Webb (1991;1992) reported in review of research on co-operative learning that the less verbally participative students in a group can and *do learn as well* as the more prominent group members.

- ***Person-to-person interaction***

In this interaction, not only a relationship with what is to be learnt is established, but also an interdependent one. This social relationship can be achieved when learners engage in assisting, helping, encouraging and supporting one another while solving a problem (Johnson & Johnson, 1990:103-106 and Sharan & Sharan, 1987:22).

- ***Social co-operative skills***

Social co-operative skills are important in any small group discussion as learners engage in the exchange of ideas, the construction of meaning and the interplay of personalities (Wilkerson, 1996: 29). Some of the social skills involved in co-operation include listening, soliciting opinions, encouraging explicitness, highlighting differences of opinions, synthesizing viewpoints and co-operating in the execution of a task (Wilkerson, 1996: 29). Johnson & Johnson (1987:109-123) give a broad summary of social co-operative skills which are related to those described by Wilkerson (1996):

- Communication skills.
- The skills to establish and maintain a climate of trust in one another.
- The skills to handle conflict in a constructive way.

Skills which also contribute towards effective group functioning are *equal opportunity* amongst group members and *rotation of roles* (Basson, Oosthuizen, Duvenhage & Slabbert, 1983:59). The different roles which learners can take on, depend on both the skills involved for executing the *learning task* as well as the *social skills*. These roles must change and rotate frequently to give learners the opportunity to practice each of the roles.

- ***Group size and group composition***

Groups may vary in size from two to six learners, but Kagan (1992:62) suggests that four is an ideal number. According to him this is the smallest group size which allows maximum interactive communication. Wilkerson (1996:24) however, takes a realistic view of group size when she says that group size is determined by the number of learners, how many facilitators or tutors can be recruited and how many rooms are available. Hare (1962) who reviewed studies on group size found that most PBL programmes prefer groups of eight or fewer, but concluded that five members were the most productive group size. Slabbert (1996:234) suggests that groups should be as heterogeneous as possible in terms of sex, ability, skills, races and culture. By doing this groups are provided with the biggest variety of resources available. Learners also learn how to deal with diversity and multiculturalism, which is a reality in post-modern classrooms.

3.2.2 Norms and Standards for South African Educators who need to facilitate OBE

The training practice of teachers should empower pre-service teachers to become competent in the designing and facilitation of OBE learning opportunities reflecting OBE charateristics. The aforementioned section gives a generic overview of what needs to be addressed in future OBE teacher training programmes. Since this is generic and very broad, the Norms and Standards for Educators (Department of Education, 2000a) can give more precise indication as to the "what" and "how" that need to be accommodated in OBE teacher training programmes for the South African context.

The exit level outcomes to be demonstrated by future teachers are described as roles in the policy document called the Norms and Standards for Educators (2000a). Exit level outcomes are the learning demonstrations that define a system's ultimate expectations for learners, occurring at or after the end of the learners' study for a qualification (Spady, 1994b:190). Learners cannot graduate until they have achieved all the exit level outcomes of a programme (Killen & Spady, 1999: 201). It is worthwhile, at this stage, to briefly investigate what is expected of future teacher training in South Africa, before exploring a particular teaching strategy -PBL - and its possibilities to operationalise OBE.

The "Norms and Standards" document defines seven roles for educators and describes a set of associated competences for each role. (Department of Education, 2000a:15-22). These seven roles embody the exit level outcomes of the teaching profession for schooling. The competences have further been divided into practical, foundational, and reflexive competences which provide the assessment criteria (Department of Education, 2000a). Practical competence is described as

> *the demonstrated ability, in an authentic context, to consider a range of possibilities for action, make considered decisions about which possibility to follow, and to perform the chosen action (2000a:10).*

Foundational competence entails

> *the demonstration of the understanding of the knowledge and thinking which underpins the actions taken (2000a:10).*

Reflexive competences have been mastered when a learner

> *demonstrates (the) ability to integrate or connect performances and decision making with understanding and with the ability to adapt to change and unforeseen circumstances and explain the reasons behind these actions*

(2000a:10).

The seven roles which prospective teachers will need to play are the following (Department of Education, 2000a:13-22):

- **Mediator of learning**: Teachers will mediate learning in a manner which is sensitive to the diverse needs of learners; construct learning environments that are appropriately contextualised and inspirational; communicate effectively showing respect for the differences of others. In addition teachers will demonstrate a sound knowledge of subject content and various principles, strategies and resources appropriate to teaching in a South African context.

- **Interpreter and designer of learning programmes and materials:** A teacher will understand and interpret provided learning programmes, design original ones, identify the requirements for a specific context of learning, select and prepare suitable textual and visual resources of learning. The teacher will also select, sequence and pace the learning in a manner sensitive to the differing needs of learners.

- **Leader, administrator and manager:** The teacher will make decisions appropriate to the level, manage learning in the classroom, carry out classroom administrative duties efficiently and participate in school decision-making structures. These competences will be performed in ways which are democratic, which support learners and colleagues, and which demonstrate responsiveness to changing circumstances and needs.

- **Scholar, researcher and lifelong learner:** The teacher will achieve ongoing personal, academic, occupational and professional growth through pursuing reflective study and research in the Learning Area, in broader professional and educational matters, and in other related fields.

- **Community, citizenship and pastoral role:** The teacher will practise and promote a critical, committed and ethical attitude towards developing a sense of respect and responsibility towards others, one that upholds the constitution, and promotes democratic values and practices in schools and society. Within the school, the teacher will demonstrate an ability to develop a supportive and empowering environment for the learner and respond to the educational and other needs of learners and fellow educators. In addition the teacher will develop supportive relations with parents and other key persons and organisations based on a critical understanding of community development issues.

- **Assessor:** The teacher will understand that assessment is an essential feature of the teaching and learning process and know how to integrate this process. The teacher will have an understanding of the purposes, methods and effects of assessment and be able to provide helpful feedback to learners. The teacher will design and manage both formative and summative assessment in ways that are appropriate to the level and purpose of the learning and meet the requirements of accrediting bodies. Detailed and diagnostic records must be kept. The teacher will also know how to interpret and use assessment results to feed into the processes for the improvement of learning programmes.

- **Learning area/subject/discipline/phase specialist**: The teacher will be well grounded in the knowledge, skills, values, principles, methods, and procedures relevant to the discipline, subject, Learning Area and/or phase of study. The teacher will know about different approaches to teaching and learning and how these may be used in ways which are appropriate to the learner and the context. The teacher will have a well developed understanding of the content knowledge appropriate to the specialisation, which is technology education, for the purpose of this research.

A pre-service teacher who can demonstrate these competences is considered competent to perform the roles and have achieved the exit level outcomes of the qualification (Department of Education, 2000a:15-17). Some of the competencies most relevant for this research are included in the following excerpts from the Norms and Standards Document presented in detail in Table 3.1:

Table 3.1: Selected roles to be performed by prospective teachers

ROLE: LEARNING MEDIATOR
Practical competencies
Using key strategies such as higher level questioning, problem-based tasks and projects; and appropriate use of group work, whole class teaching and individual self-study.
Adjusting teaching strategies to: Match the developmental stages of learners, meet the knowledge requirements of the particular Learning Area; cater for cultural, gender, ethnic, language and other differences among learners.
Using media and everyday resources appropriately in teaching including judicious use of: common teaching resources such as text-books, chalkboards and charts; other useful media like over head projectors, computers, video, audio, popular media and resources, like newspapers, magazines and other artefacts form everyday life.
Foundational competencies
Understanding the pedagogic content knowledge – the concepts, methods and disciplinary rules- of the particular Learning Area being taught.
Understanding the learning assumptions that underpin key teaching strategies and that inform the of media to support teaching
Reflexive competencies
Defending the choice of learning mediation action undertaken and arguing why other learning mediation possibilities were rejected.
Reflecting on how teaching in different contexts in South Africa effects teaching strategies and proposing adaptations.

ROLE: INTERPRETER AND DESIGNER OF LEARNING PROGRAMMES AND MATERIALS
Practical competencies
Adapting and/or selecting learning resources that are appropriate for age, language competencies, culture and gender of learner groups.
Designing original learning resources including charts, models, worksheets and more sustained learning texts.

Foundational competencies
Understanding the principles and practices of OBE, and the controversies surrounding it, including debates around competence and performance.
Understanding the Learning Area to be taught, including appropriate content knowledge, pedagogic content knowledge, and how to integrate this knowledge with other subjects.

(Department of Education, 2000a:15-17)

One specific strategy and its multiple different dimensions will be the centre of attention in the next sub-section, namely, problem-based learning.

3.3 Problem-based learning: A teaching strategy with the potential to operationalise OBE in practice

One of the major professional responsibilities of teachers is to design and implement meaningful learner-centred learning experiences, which will lead to mastery of the outcomes (Cockburn, 1997:7). Consequently, teachers need to have a sound base of academic and practical competence regarding the variety of teaching strategies and methods, as was indicated by the Norms and Standards for Educators (2000a).

3.3.1 Defining teaching strategies and methods

Before one particular learner-centred strategy will be discussed, it is necessary to state what teaching strategies and methods are. Often in the literature these terms are used interchangeably when in fact describing the same teacher-learner interventions. In this research, a teaching strategy is defined as a "*broad plan of action for teaching activities with a view to achieving an aim*" (Loubser, 1993:143).

While strategies emphasise the broad actions for teaching and learning, refinement of these actions takes place on a micro level when programming for a particular unit of learning is done. Part of the refinement may involve the selection and sequencing of teaching and learning methods to be used when deploying the broad teaching strategy.

A method can be defined according to Fraser (1993:153) as a *"planned procedure intended* *to achieve a specific aim.* The procedure referred to in this general definition can be interpreted in an educational context as *"the various classroom activities planned by the teacher"* (Fraser, 1993:143).

Problem-based learning will be interpreted as a teaching strategy within the context and purpose of this research. PBL does not only refer to the "how" mechanism of teaching, but also to the entire approach which was used to organise the curriculum of the pre-service teachers.

3.3.2 Defining problem-based learning

A brief overview of the history of problem-based learning (PBL) provides evidence that the medical field has pioneered a major effort in using PBL as a way of curricular renewal. Albanese & Mitchell (1993) who have studied the literature on PBL from 1972 to 1992, chronicle that it has existed in medical schools since 1960. McMasters University Faculty of Health Sciences in Ottawa Canada, introduced PBL as a tutorial process to promote learner-centred education for lifelong learning (McCombs, 2000). Harvards' Medical School utilized a hybrid problem-based model of lectures, tutorials, conferences and clinical problems. Michigan State University College of Human Medicine, also implemented a problem-solving curriculum.

Up to the mid 1980's, PBL evolved as a more descriptive process than analytical. Research mostly related to learners' perceptions and performance with very few impact studies on graduates, faculty, the institution or the profession. Most evidence came from a handful of medical schools with a few examples of coherent PBL curricula for other professions, leaving curriculum designers with not much evidence if they wanted to restructure curricla around problems. In the USA various other university medical schools who are also currently using PBL are Bowman, Gray, Boston University, Georgetown Illinois, Southern Illinois University, Tufts, Mercer, Indiana, Northwestern, Hawaii, Missouri-Columbia, Texas-Houstan and Pittsburgh. Other universities outside of the USA who are also using PBL include Maastricht (Netherlands), Newcastle (Australia), Canada, Denmark, South Africa, Finland, and Sweden. The recent advantages of information networks such as the internet, e-mail, PBL-dedicated journals, conferences and books have facilitated a wide spread usage of PBL (Everwijn, Bomers & Knubben, 1993:426, Kaufman & Mann, 1996:1096 and McCombs, 2000).

Different reasons exist for implementing PBL as curriculum transformation. Albanese & Mitchell (1993) report that physicians believed that a better way exists for training medical students, avoiding hours of lectures and then testing their ability to recall bits of trivia. Barrows & Tamblyn (1980:7) distinguish between the roles of *content knowledge* and *professional skill* in medicine and explicate that traditional curricula put too little emphasis on the latter. Everwijn, Bomers & Knubben (1993: 426) discussing educational management, stretch the belief of the physicians when they state the following:

> *For a long time it has been assumed that a curriculum designed around disciplines and functional areas would adequately prepare students for future management positions. ... Real life business problems supersede the boundaries of individual disciplines and functional specialisms. They require an interdisciplinary perspective and interdisciplinary know-how and expertise.*

It can be concluded that a major reason for using PBL in professional training, is to bridge the gap between *knowledge acquisition and ability to apply* it in practice (Barrows & Tamlyn, 1980, Everwijn, Bomers & Knubben, 1993 and Gallagher & Stepien, 1996).

In the aforementioned training of physicians and educational managers, PBL has been used as a teaching strategy in one of three ways. In both the aforementioned training, PBL was used as a basis for an entire curriculum, course or learning programme **through** which teaching in an integrated manner could take place. This strategy advocates starting with the problem, rather than with the problem-solving tools. PBL and consequently problem-solving strategies can also be studied as a theme, for example by pre-service education students. In this regard they learn **about** problem-solving and the processes involved in solving problems. A third way of using PBL is where teachers teach **for** problem-solving where learners have to acquire the knowledge, understandings and skills which are useful for solving problems.

In this research PBL was used as a teaching strategy **through** which the pre-service technology teachers were trained. Being pre-service teachers, they also had to learn **about** problem-solving, since they had to design and facilitate PBL experiences in practice after their training period themselves. Since they had to be prepared for technology education, they also had to learn how to solve problems, especially of the kind associated with technology. This approach of **'teaching teachers the way they are expected to teach'** is believed to enhance transfer of their competencies to real classrooms, thus improving the quality of their future teaching practice.

With this background knowledge of PBL a definition for PBL as a teaching strategy can be presented (Barrows & Tamlyn, 1980:18):

> *(Problem-based learning is) the learning that results from the process of working toward understanding or resolution of a problem. The problem is encountered first in the learning process and serves as a focus or stimulus for the application of problem-solving or reasoning skills, as well as for the search for or study of information or knowledge needed to understand the mechanisms responsible for the problem and how it might be resolved. The problem is not offered as an example of the relevance of prior learning or as an exercise for applying information already learnt in a subject-based approach. A problem in this context refers to an unsettled, puzzling, unsolved issue that needs to be resolved. It is a situation that is unacceptable and needs to be corrected.*

Nickerson, Perkins & Smith (1985:222) elaborate on this definition when saying that by simply giving an answer to a question or applying a known principle to explain an observation is not PBL and that the learning required of a learner in PBL is active, not passive. Barrows & Tamlyn (1980:83) explains what activity means when they say that

> *the student does not listen, observe, write, and memorise; instead, he is asked to perform, think, get involved, commit himself, and learn by trial and error. He is asked to learn both cognitive reasoning skills and psychomotor skills ... and to identify learning needs made apparent by his work with a problem.*

For any definition to be realised in practice, it must be translated into some form of a curriculum framework or model.

3.3.3 A problem-based curriculum framework and problem-based learning models

Several researchers have worked on the design and development of problem-based curricula (Barrows, 1986; Ross, 1991; Schmidt, 1983-1993 and Walton & Matthews, 1989). The overview of a curriculum framework for PBL presented, is based on the work of Ross (1991:36-37). This is shown in five steps below:

1 The first component of the framework deals with who selects these problems. Problems can be selected by the following role players:

- A curriculum design team. If applicable problems do not exist they can design or simulate them or get them from problems listed by the learners.
- By the learners as a group or as individuals.

2 This component provides a framework for the purpose of a problem which is selected. It defines the area of knowledge to be covered at least. The problem can be selected with the following purposes in mind:

- To ensure that learners cover a pre-defined area of knowledge.
- To help learners generate relevant ideas and learn important concepts, skills and techniques.
- A problem can be selected for its suitability for leading the learners to the "field" or parts of it.
- A problem can be selected for its intrinsic interest, potential to motivate or overall importance.
- A problem can be selected because it represents a typical problem to be faced by the profession.

3 This component deals with the form in which the problems are presented to the learners. For example, the design team presents the learners with a problem as a "trigger" and the learners define the problem from the "trigger" as a set of questions. The form that a problem can take could be the following:

- An authentic event or simulation of an event – a "trigger".
- A descriptive statement.
- A set of questions.

4 This dimension deals with the defining of resources needed to solve the problems. The resources to be used by learners can be selected as follows:

- The design team can select all the resources needed to be studied by the learners.
- The learners themselves can select from a resource "package" which has been compiled by the design team.
- The learners themselves can select from any resources available to them.

5 Learners can work in the following manner:

- In groups with a facilitator.
- In groups without a facilitator.
- As individuals who are free to contact the facilitator when needed.

In most circumstances, learners will be expected to work in all of these ways depending on the type of problem and the stage of the problem-solving process. The aforementioned framework must be interpreted as descriptive and flexible, rather than prescriptive. All the steps mentioned are not mutually exclusive and variations can be made as resources allow. This framework may be adapted to be in coherence with different PBL models.

A very basic and general PBL model is presented by Barrows (1986) for medical learners:

- The problem is *encountered* by the learners.
- *Problem-solving* takes place by using clinical reasoning skills and identifying learning needs in an interactive group process that involves self-study and applying new gained knowledge to the problem.
- The PBL process ends with learners *evaluating* the information and resources they have

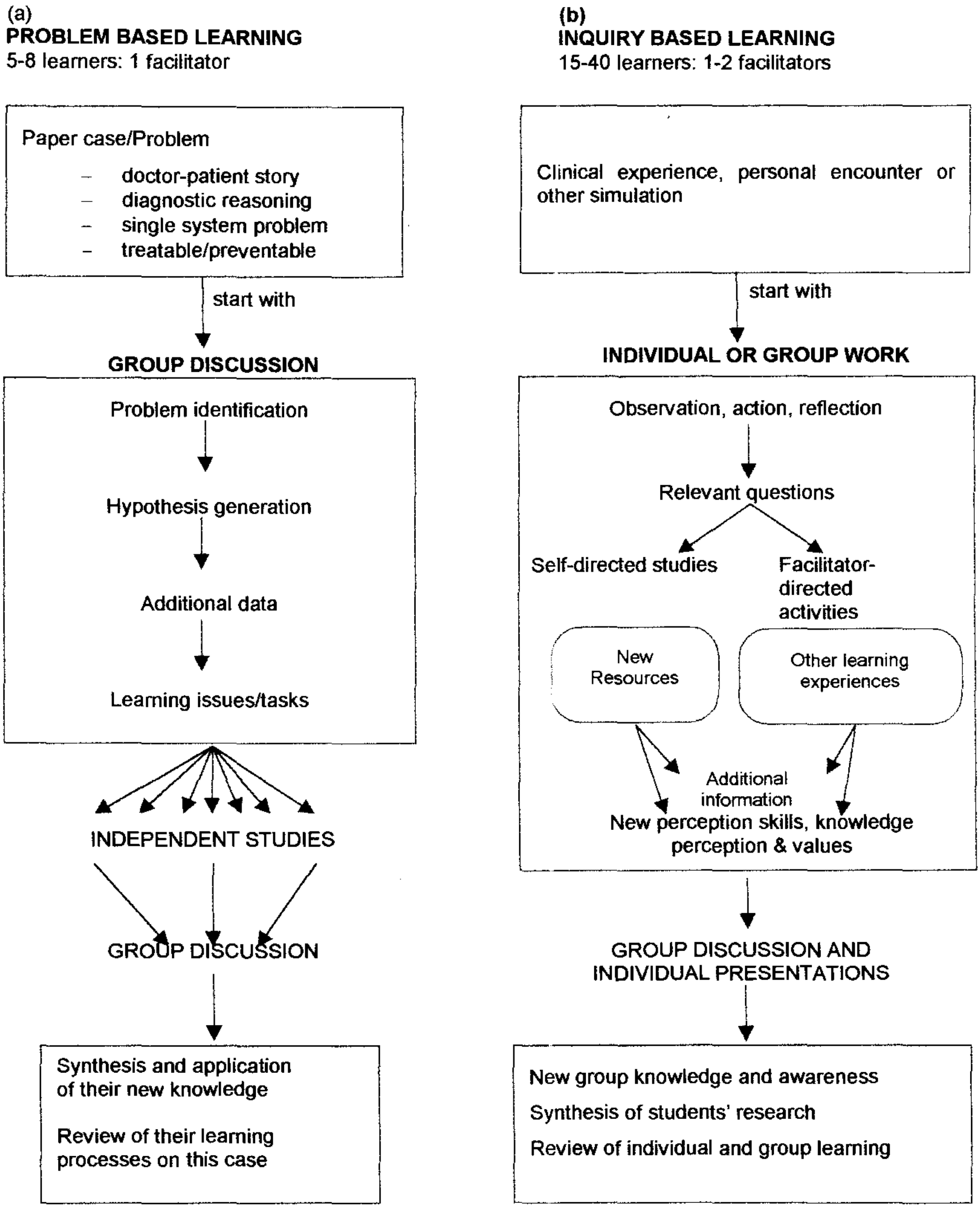
used in the solution by focusing on how they could have managed the problem better.

Savoie & Hughes (1994) also present a PBL model in terms of what a facilitator has to do:

- Identify problems useful to learners.
- Place the problem in context for the learner to make it authentic.
- Structure the subject content around the problem and not the discipline.
- Make learners responsible for their learning and problem solutions.
- Advance collaboration by forming learning groups. If learners have no practice in group work, they need to be coached in the process of group work and social interaction skills.
- Demand all learners demonstrate their learning by presenting a product or constructing and making a public presentation.

Two other models, also developed for the field of medical training, but which may be adapted for any PBL learning environment, are presented below (Williams & Williams, 1997:94) These models are basically similar and have been adapted to include terminology used in this research. The one model is representative of *inquiry-based learning*. Since the problem in PBL is something that gives rise to doubt, uncertainty, a question or an inquiry that starts from given conditions, PBL can be viewed as a form of inquiry based learning (Van der Horst & McDonald, 1997). Dewey (1929:189) who advocates "*reflective inquiry*" explicates the role of problems in reflective inquiry when he states that "*all reflective inquiry starts from a problematic situation*". For Dewey (1929) the value of this form of learning is not only the fact that problems trigger reflective inquiry, but that it engages learners in looking for problems. Learners are problematising their experiences with problems to understand them more fully (Hiebert, Carpenter, Fennema, Fuson, Human, Murray, Olivier & Wearne, 1996:12-21).

Figure 3.1: Models for problem- and inquiry-based learning used in medical training



The similarities between the basic components of these models for PBL and the models used in the technological design process, are remarkable. These similarities will be highlighted in Section 3.4 where technology education is discussed.

Cognisance should be taken of the fact that *group work* or *collaboration* between learners features at some stage during the PBL process, as indicated by the models on PBL. It seems then that collaboration in terms of group work or co-operative learning is one of the characteristic features of PBL. This characteristic, as well as others will briefly be discussed now.

3.3.4 Characteristic features of problem-based learning

A number of characteristic features exist for PBL, regardless of the context in which it is applied. Some of the characteristics are discussed below.

3.3.4.1 Learner collaboration and co-operative work

In the discussion on OBE in Section 3.2.1, learner collaboration in terms of group or co-operative learning was addressed. Different reasons for incorporating collaboration amongst learners somewhere in the process of PBL exist. Williams & Williams (1997:93) recommend collaboration in order to foster a supportive learning environment. The rationale for a supportive learning environment is stretched by Bridges & Hallinger (1992) when they state that it allows for an emotional tone that resembles real life situations. Also when projects go awry, the PBL group learner gains insights into how they deal with frustration, disappointment and socio-emotional conflict.

However, Brown & Palincsar (1989) emphasise that conceptual change in collaborative PBL is more the result of processes of co-elaboration and co-construction due to a shared cognitive conflict rather than to a social one. The cognitive conflict experienced amongst learners, also induces meta-learning. When collaborating, learners often find themselves at loggerheads with a fellow learner which, in fact, "forces" the learners to reflect on their own ideas, premises and motives.

3.3.5 Conceptual dimensions of PBL

PBL is hypothesised to have a number of advantages over traditional strategies for teaching and learning, associated with cognitive processes it is believed to stimulate (De Grave, Boshuizen & Schmidt, 1996:321). Schmidt (1983, 1993) emphasises the cognitive effects of PBL in terms of *knowledge activation* and *elaboration* and presented empirical evidence for this claim (Norman & Schmidt, 1992).

3.3.5.1 Information processing and constructivist theory

The major theory which Albanese & Mitchell (1993) and Barrows (1986) base their support for PBL on, is *information-processing*. The essence of this theory holds that what learners will learn is influenced by their prior knowledge and past learning (Ausubel in Novak & Gowin, 1984:7). This support for PBL is in line with the constructivist theory of learning. This theory states that knowledge is constructed through a process of reflective abstraction, that prior cognitive constructs effect the construction of new meaning and that cognitive structures are in constant state of evolution (Seifert & Simmons, 1997:90 and Novak & Gowin, 1984:4-5). Therefore, for effective meaning construction to take place, the teaching strategy must activate a learner's prior knowledge. Norman (1988) indicated that PBL is highly compatible with the notion of stimulating prior knowledge. In a study where PBL was used in an undergraduate Construction Management course at the Western Australian Institute of Technology, PBL learners reported "*less book type research and more use of previous learning*" (Davis, 2000:7).

It is especially in the first stages of PBL, namely during *problem-analysis,* where learners need to reflect on prior knowledge to become aware of the mismatch or a gap in their prior knowledge and the knowledge and competencies needed to resolve the problem (De Grave, Boshuizen & Schmidt, 1996:323-324). This conflict which results from a disagreement between prior knowledge and the problem, will lead learners to conceptual change. In fact, inducing cognitive conflict within learners to establish conceptual change is an axiom of PBL (De Grave, Boshuizen & Schmidt, 1996:323).

3.3.5.2 Recall and transferability of knowledge

A major advantage of PBL is that a problem provides a *context* for learning. Knowledge is much better understood and recalled in the context in which it was originally learnt (Norman, 1988). In the process of solving-problems, much searching takes place and according to Kingsley (1946) we learn when we recognise the objects of our search. Bridges, Hallinger & Hallinger (1992) explain that information is better understood, and thus remembered when learners get the opportunity to *elaborate* on it by means of searching. Confrontation with the problem, as well as with other learners' knowledge of the problem, helps learners to elaborate on their knowledge (De Grave, Boshuizen & Schmidt, 1996).

Another advantage is that new information and skills acquired by a learner within a context simulating reality through problems, will be more easily transferred to a related "real" context or problem situation. The same PBL undergraduate learners who did the Construction Management course noted that the PBL learning was "more practical and realistic" (Davis, 2000:7). It seems that the power of transferability is vested in the authenticity of problems used in the classroom.

3.3.5.3 Meta-cognitive processes associated with PBL

Effective problem-solving demands conscious and/or unconscious utilisation of meta-cognitive processes. The purpose and role of meta-cognitive processes in PBL will be clearly comprehended when metacognition is clarified. Flavell (1976:232) defines meta-cognition in the following manner:

> *One's knowledge concerning one's own cognitive processes and products...(and) the active monitoring and consequential regulation of those processes in relation to the cognitive objects or data on which they bear.*

Nisbet & Shucksmith (1986:8) add to their definition the concepts of *awareness* and *reflection*, which are necessary for effective decision-making in problem-solving. They also refer to metacognition as a "seventh sense":

> *(The) seventh sense is meta-cognition, the awareness of one's own mental processes, the capacity to reflect on how one learns, how to strengthen memory, how to tackle problems systematically – reflection, awareness, understanding, and perhaps ultimately control, the seventh sense is a relatively undeveloped sense among people generally.*

In the context of problem-solving, or any learning for that matter, reflection is a key concept. Slabbert (1996:142) explains that reflection implies that there must be something to reflect upon such as prior constructed knowledge or new knowledge being constructed. By reflecting and thus being aware of the progress or problems encountered in the process of finding solutions and constructing meaning, learners will be able to *control* their own learning processes. In other words the locus of control can shift from an external one such as a teacher to an internal locus of control in the learner himself. Consequently the learner is empowered to become an autonomous, independent and lifelong learner (Slabbert, 1996:142). This in fact, coincides with the purpose of PBL.

A link exists between metacognition and learning and because of this close association of metacognition with effective learning the term 'meta-learning' came into existence (Baird, 1986:263, Biggs, 1985:185 and Ford, 1981:250). Slabbert (1996:144) defines meta-learning as follows:

> *Metalearning comprises the higher order learning activities or the control activities of learning (superstructure) such as planning, execution, monitoring and evaluation. These higher order learning activities exert control over the lower order learning activities or executive activities of learning. Metalearning guides and directs (controls) the learning process.*

The nature of PBL both demands the utilisation of meta-learning and it operationalises meta-learning. In the experimental group intervention in this research, a meta-learning checklist by the name of "research checklist" was included in the resource kit for each school learner who was part of the PBL intervention. It was argued that this meta-learning checklist could initially serve to make learners aware of the meta-learning process while actually dealing with the problem to be solved. The idea of meta-learning strategies is to finally be internalised and automatised by learners, but they first need to become aware of meta-learning strategies and its value within a context and not in a vacuum.

3.3.6 PBL and its effects on learner attitudes and motivation

Numerous studies have examined PBL processes and outcomes in terms of cognitive and meta-cognitive outcomes, especially in the training of health care professionals (Albanese & Mitchell, 1993; Barrows, 1986; Barrows & Tamblyn, 1980; Bridges & Hallinger, 1992 and De Grave, Boshuizen, & Schmidt, 1996). This section will briefly look into current research findings regarding learners' *attitudes* towards this strategy. One of the aims of this research is also to get some feedback regarding attitudes of *learners* who were exposed to PBL, by *pre-service teachers* who were trained through PBL as a strategy.

In a study by Norman & Schmidt (1992) it was found that PBL enhances *intrinsic interest* in content. This finding is in line with the aims of inquiry learning as described by Dewey (1929) which implies that once content is treated as a problem to be solved, only then learners examine it more carefully, begin to understand it, gain control over it and use it more effectively to their advantage. This sense of cognitive achievement promotes intrinsic interest which in turn results in positive attitudes towards the curriculum. The fact that learners are challenged through problems, can assure that they derive great satisfaction from discovering new knowledge for themselves which may enhance a personal pride and positive self-concept (Cobb, Yackel, Wood, Wheatley & Merkel, 1998).

Kaufman & Mann (1996: 1096) found that the attitudes of second year medical students from the Dalhousie University Faculty of Medicine, were significantly more positive than the conventional curriculum students. The PBL learners had more positive attitudes towards their learning environment regarding the sub-scales of academic and faculty enthusiasm, democratic decision-making and vigorous class discussions. They did find however, that traditional learners were more positive than the PBL learners about learner interactions in their classes. The PBL learners appeared to form several factions or cliques within their class. They contributed this happening to the fact of the intensity of the small group process and that learners became acquainted at a deeper level more quickly than in the lecture-based curriculum. A lesson to be learnt form this, is to rotate members in a group to allow learners to work with as many learners as possible on different problem tasks if the forming of cliques within one class is to be inhibited.

However, it was found by Albanese & Mitchell (1993:68) that learners experience a PBL environment more nuturing and enjoyable than conventional classrooms. Compared with traditional curriculum learners the PBL learners were more highly rated with regard to faculty attitudes, learner moods, class attendance and measures of humanism (Vernon & Blake, 1993:68).

In an Educational Leadership Programme which was conducted using PBL, significantly higher evaluations on "value of the course" and "performance of the professor" were received, as compared to learners in the traditional methods course (Tanner, Galis & Pajak 1997). Tanner, Galis & Pajak (1997:10) reported that *"students liked the approach and thought the professor did a superior job of teaching".* Their colleague who facilitated PBL learning for the first time did not receive the same positive evaluations initially and this is contributed to the fact that he had to work through the experimental phase where PBL materials had to be developed for the first time. In later PBL programmes, however, his evaluations actually surpassed his former evaluations in the traditional classes (Tanner, Galis & Pajak , 1997:10). Finally, for maximum benefit to the student, they concluded that **special training** by a formal institute such as the PBL Institute at Stanford University or mentoring, is needed by the facilitator before taking on the job of employing PBL activities successfully in the classroom (Tanner, Galis & Pajak , 1997:10).

In a critique on PBL in health care profession training, Bruhn (1997:69) reports the following findings in general and on motivation. He states that Berkson (1993) found that health care graduates going through PBL are not necessarily better prepared for practice with respect to clinical knowledge and its application. PBL graduates do however have a broader range of interpersonal skills, a greater appreciation of the complexity of problems and the resources available for a solution, and a *heightened motivation* for continued self-learning (Norman & Schmidt, 1992 and Williams, Saarinen-Rahikka & Norman, 1993).

High school research on an economics PBL project, undertaken by Seifert & Simmons (1997) also reported qualitative results reflecting the general attitude towards this strategy. Learners indicated the following:

> *They learned more in this project than they had in any course in high school. They particularly liked the opportunity to research a topic and suggest a solution without trying to arrive at some pre-conceived answer. Some of the students felt they needed and wanted more direction early in the process, but by the end of the project they felt fulfilled and indicated this process would be most helpful in the future (Seifert & Simmons, 1997: 97).*

In this project it was found that the parents were very supportive and helpful in using this approach. Several of the parents indicated that they got the impression that it was the first time that their children were truly challenged to think on their own since the beginning of their elementary or secondary school years. Parents especially liked the concept of making their child responsible for some of his or her own learning.

From the reported findings in the aforementioned section it seems that learners who have experienced PBL in different ways over varying time spans, have varying attitudes towards this strategy, depending on the degree of experience or expertise of the facilitator implementing PBL. It does, however seem that PBL induces intrinsic motivation, which results in learners who are motivated for self-directed learning – a premise for lifelong learning.

3.3.7 PBL and knowledge acquisition: Depth vs breath

Part of the rational for implementing PBL in teaching and training is the overcoming of the gap between *knowledge acquisition* and the *ability to use this knowledge* (Everwijn, Bomers & Knubben, 1993:425). This has the implication that some of the content topics in a regular syllabus have to be reconsidered to make space for the higher cognitive processes involved in solving a problem, which usually uses more time than only covering topics. In a study by Gallagher & Stepien (1996:257) they report that a continuous barrier to the implementation of PBL curricula is the perception that it "*inevitably results in lower levels of content acquisition*". They challenged this assumption in a study which compared high school learners' history scores on a multiple-choice standardised test (National Assessment of Educational Progress History Test) after traditional and problem-based teaching strategies were used. In their study, 50% of the school year was devoted to PBL, where there was no direct instruction of content to be 'covered' either before, during or after the problem-based intervention. To minimize the potential for traditional learning they also did not prescribe any textbook readings.

The statistical evidence provided shows that in their case, learners in the PBL course, retained as much factual information as learners in the other classes and that this strategy "*did no harm*" in terms of knowledge acquisition (Gallagher & Stepien, 1996:270). They claim that this particular study adds to the growing body of evidence that teaching for depth of understanding also facilitates retention of content facts.

In another of the existing studies, the Harvard Social Studies Project obtained results supporting the notion that higher order thinking induced by PBL is an avenue to factual, content learning - equivalent levels of content acquisition were found among learners in problem-based and traditionally structured classes (Olivier & Shaver, 1963).

Reporting on research findings in PBL without looking at the medical field where extensive work has been done in this regard, will not be complete. One study by Baca, Mennin, Kaufman & Moore-West (1990) found that medical learners in a traditional and PBL curriculum received equivalent scores in their clinical blocks during the last two years of medical school. In a similar study comparing McMaster University, which has a PBL curriculum, and the traditional McGill University medical learners, the PBL learners were found to hypothesise more, but they arrived at the correct diagnosis less often then the non-

PBL learners (Patel, Groen & Norman, 1991). PBL learners at Rush Medical College performed better on patient interviews, ability to obtain and summarise histories and problem-solving than their counterparts who did not experience PBL (Goodman, Brueschke, Bone, Rose, William & Harold, 1991). Shin and his colleagues also compared PBL and non-PBL learners and found that their clinical knowledge of hypertension management was more current than that of their counterparts (Shin, Haynes & Johnston, 1993). In a study of medical interns who were assessed by their supervisors, it was determined that the majority of the graduates were graded 'above average' in four clinical subjects but below average in knowledge of anatomy.

In defense of the PBL strategy Barrows & Tamlyn (1980) (Nickerson, Perkins & Smith, 1985:222) give a perspective on this debate which will serve as a conclusion for a matter which will continue as long as different strategies for teaching and learning exist. They say that medical learners often complete training by passing all the knowledge exams, but still do not know how to *practice* medicine effectively. In support of their view that knowledge that is not used is not well retained anyhow, they cite Miller's (1962) finding that before students graduate, they typically forget most of what they learned in their first year anatomy and biochemistry courses. A major mathematics student summed up the many mixed opinions with this short critique: "*You never get a chance to ask when am I gonna use this, because you always just did*" (Ulmer, 2000:5). This comment captures the essence of the value of PBL, which is to make learning meaningful, relevant and hands-on in authentic learning environments.

These sections briefly reviewed some of the various findings regarding the depth and breadth of knowledge in either PBL or traditional curricula. It seems that is should be accepted that PBL does not conform to or necessarily yield the results normally emanating from traditional curricula and vice versa. This particular research will also attempt to give some answers on the depth versus breadth debate regarding knowledge acquisition and application.

3.3.8 Designing a problem-based learning task

In PBL a problem serves as the initial stimulus and framework for initiating and maintaining learning. In programming or planning for OBE it should be kept in mind that the outcome should not be designed around the problem, but vice verse. Once a facilitator is very clear about the outcome(s) to be demonstrated by learners after a learning task, only then should problems be identified, selected or designed. Since problems are the 'triggers' of meaningful learning, it is *crucial* to understand the nature and criteria for identifying, selecting or designing them.

3.3.8.1 The nature and criteria for problems in problem-based learning

Since problems are the triggers for initiating and maintaining learning in a PBL environment, the problem designers (facilitators of learning) need to be knowledgeable about the nature and criteria to which problems have to adhere. Killen (1998b:118) contends that the real challenge is not to find problems, but to find suitable problems which will lead learners in the attainment of new knowledge, skills and attitudes. Killen (1998b:118) continues to say that this is most likely to occur when a problem requires learners to relate new knowledge with prior knowledge, make explicit what they understand and do not understand, and learn concepts well enough to explain them to others as part of the understanding process.

Duch (1996) reports that many faculty who have implemented PBL in their courses and learners who have taken those courses agree on several factors that are essential for good problems. He presents these common factors as a set of generic characteristics which are present in effective problems. These characteristics are the following:

- An effective problem must first engage learners' interest and motivate them to probe for deeper understanding of the concepts being introduced. It should relate the subject to the real world, so that learners have a stake in solving the problem.

- Good problems require learners to make decisions or judgements based on facts, information, logic and rationalisation. Learners should be required to justify all decisions and reasoning based on the principles being learned. Problems should require learners to define what assumptions are needed and why, what information is relevant, and what steps or procedures are required in order to solve them.

- Co-operation from all members of the learner group should be necessary in order to effectively work through a good problem. The length and complexity of the problem or case must be controlled so that learners realise that a "divide and conquer" effort will not be an effective problem-solving strategy. For example, a problem that consists of a series of straight-forward "end of chapter" questions will be divided by the group and assigned to individuals and then reassembled for the assignment submission. In this case, learners end up learning less and not more.

- The initial questions in the problem should have one or more of the following characteristics so that all students in the groups are initially drawn into a discussion of the topic (a) open-ended, not limited to one correct answer (b) connected to previously learned knowledge and (c) controversial issues that will elicit diverse opinions. This strategy keeps the learners functioning as a group, drawing on each other's knowledge and ideas, rather than encouraging them to work individually at the outset of the problem.

- The content outcomes of the course should be incorporated into the problems, connecting previous knowledge to new concepts, and connecting new knowledge to concepts in other courses and disciplines.

In the field of medical education it is suggested that problems should be chosen

- that have the greatest frequency in the usual practical setting
- that represent life-threatening or urgent situations
- that have a potentially serious outcome in terms of morbidity or mortality, in which

intervention – preventive or therapeutic – can make a significant difference in prognosis

- that are most often poorly handled by doctors in the community.

(i) Authentic, real-life problems

The type of problems can range from a series of short-, intermediate or a single long term problem, either real or simulated (Hoffman & Ritchie, 1997:98 and Wilkerson, 1996:27). Killen (1998b:118) divides problems into three categories namely, routine, non-routine and open-ended. Routine problems are solved by using a known algorithm and can be related to practice and drill exercises. In non-routine problems the method of solution has to be discovered and is part of the problem-solving process. Open-ended problems are often real-life orientated and may be solved through different methods. In the literature a central, overarching criterion constantly comes to the fore which deals with the **authentic, real life** essence of which ever type of problem is designed. Seifert & Simmons (1997:92) suggest that problems should be useful to learners. To make it useful, the problem should be embedded in a richly contextualised situation. A problem should be set in terms of" *a real problem that students may have to deal with"* (Bridges & Hallinger, 1992:5-6). Real life problems are mostly ill-defined and less structured. It should not be a problem for the facilitator, but one where the learner is placed in a situation where the problem is *actually* experienced (Slabbert, 1996:116). The nature of problems to be designed for PBL environments are not the analytical type suitable for typical test or multiple choice tests which tend to

- have been formulated by other people
- be clearly defined
- come with all the information needed to solve them

- have only a single right answer which can be reached by only a single method
- be disembedded from ordinary experience
- have little or no intrinsic interest

The type of problem suitable for a PBL environment tends to

- require problem recognition and formulation
- be poorly defined
- require information seeking
- have various acceptable solutions
- be embedded in and require prior everyday experience
- require motivation and personal involvement (Claxton, 1999:32).

Eason & Green (1987:243) also provide guidelines for selecting problems which are suitable for PBL. They suggest that problems

- need to be based on the concerns of learners
- have immediate, practical effects on a learner's life
- are "actionable" in the sense that learners are able to do something to change or improve matters

- have no right answers and fixed boundaries

- require learners to use their own ideas and efforts to solve a problem

- are complex enough to require considerable effort and activity.

An authentic problem should be designed in such a way that a mismatch is created between the learners' knowledge and the problem, which will result in cognitive conflict (De Grave, Boshuizen & Schmidt, 1996:323-324). It is the cognitive conflict which challenges, elicits and evokes spontaneous self-directed learning, where the facilitator actually becomes redundant due to a learner's preoccupation with the " *challenge and enjoyment"* of the problem-solving process (Slabbert, 1996:114).

(ii) Presentation of problems

Just as important as the design of a challenging problem is the presentation of that problem. One weakness with the presentation of problems, identified by Hoffman & Ritchie (1997:100), is that many PBL courses rely primarily or exclusively on written or oral problem statements. This may adversely effect transfer between the problem situations in a course and similar ones in real life. Bridges (1992:97) offers the following advice to PBL designers:

> *To become an expert, a great deal of perceptual learning must occur, and this cannot happen unless the student learns to recognise the salient visual, auditory, and non-verbal cues. When designing a PBL curriculum, program designers should strive for a variety of modalities in presenting problems ... If students encounter only verbal descriptions of problems, they may be unprepared to deal with real problems.*

Hoffman & Ritchie (1997:103) suggest that multimedia provides multiple modalities through the creative use of text, video and audio for presenting real world problems. They contend that multimedia has the ability to increase the richness of problem presentation, which in turn increases the user's ability to interpret and understand the problem through repeated exposures (Hoffman & Ritchie, 1997:104). Repeated exposure to the problem and related materials*" at different times, in rearranged contexts, for different purposes and from different conceptual perspectives"* provides new insights and strengthens cognitive associations (Spiro, Feltovitch, Jacobson & Coulson, 1992:65).

In schools and classrooms where highly sophisticated technology is not available, which is the reality in many rural South African schools, facilitators need to tap their own creativity to **present real life problems in real life formats**, true to the nature of a field or Learning Area. In technology education, which has a need-driven nature, the need which should be addressed by the technological process, actually needs to be experienced by the technology learners themselves as far as possible. They need to 'go to the problem' instead of the problem always coming to them in a written format in the classroom. The nature and structure of some Learning Areas lend themselves more easily to real life presentations and simulations than others. In summary, creative, challenging problems need to be presented in a credible convincing way to yield the intended learning effects.

(iii) Preparing learning resource materials

In problem-based learning, learners, apart form their own resources and that of their peers and the facilitator, depend on resource materials to use during the research stage in problem-solving. In high-tech learning environments, such as universities and some schools, where written and electronic information are available in abundance, learners can be left on their own or directed to access and select the information which they need, once they are competent in using these information resources. The World Wide Web, for example is a very valuable tool and resource to because of its ability to involve learners actively in information seeking and problem-solving (Killen, 1998:139). According to Dyrli & Kinnaman (1996:56) involving learners is not enough. Teachers should have the skills to co-ordinate a range of experiences designed for a specific purpose. They should equip learners with electronic information processing skills, teach them to evaluate the information they find, help them to work independently and manage the process, in order to use their online time optimally and efficiently.

Killen (1998b:139) explains how computers can be used not only as a tool for obtaining information, but as a tool for processing, recording and reporting information. Word processors, drawing and design programmes, databases and spreadsheets may be used to manipulate, store and present data or solutions. Harris (1995) suggests that learners can also work co-operatively with peers at other schools or countries on solving problems via the Internet. Experts in the field of a particular problem may also be consulted for information or solutions to problems. Dyrli & Kinnaman (1996) caution that learners must realise that finding applicable information on the World Wide Web, is not always an easy, simple or quick process. Facilitators of learning should help learners to acquire the skills and encourage them to have resilience when their search does not produce the information they have anticipated.

In an interview conducted with four second year medical students at Pretoria University which also embraced a partly PBL approach, the students reported that the search for information on the intra- and internet, is a very time consuming process. Since so many users are accessing the network at their faculty, they report that they sometimes wait long periods to access a website with relevant information. They suggested that the frustration of wasting valuable study time while waiting will be solved if they can be issued with CD-ROM databases where the most recent and relevant information for solving a particular problem can be retrieved. This presupposed frustration might not be a problem at another institution, since the information might be managed and administered in a different way.

Designers of PBL might also decide to plan and compile their own resource packages or 'kits' as it was called in this particular research. In the South African context, where many of the schools and learners do not have access to electronic or extensive printed or multimedia services, facilitators might have to follow this route. In under-resourced schools, resource kits are vital for effective problem-solving. Schools and learners who do have access to various information resources are obviously not restricted to the resource kit only. On the contrary, learners are encouraged to expand and enrich the resource kit, and to share all newly retrieved information with their fellow group members and peers in the class.

3.3.9 Problem-solving in problem-based learning

Problem-based learning consequently implies that learners need to engage in problem-solving. To become effective problem-solvers learners need to develop competencies on how to analyse and understand a problem, how to plan and attack it, how to execute the plan and how to check if their process and solution are feasible (Killen, 1998b:125). Once learners have mastered various problem-solving strategies, they will use these as a means to learn about the content and skills of a learning programme such as technology education. These competencies are dependent on meta-cognitive processes which are responsible for controlling and managing the lower order execution or performance processes Nickerson, Perkins & Smith, 1985:20-21. "*There can be no doubt*" Sternberg says "*that the major variable in the development of the intellect is the metacomponential one. All feedback is filtered through these elements, and if they do not perform their functions well, then it won't matter very much what the other kinds of components do*" (1985:228). According to Sternberg (1981), thinking and learning skills which are used in academic and every day problem-solving, can be separately diagnosed and taught. See the discussion on meta-learning in Section 3.3.5.3. A general introduction regarding problem-solving will serve as a back drop against which the technological process as a problem-solving process, will be explored later in this chapter.

The purpose with problem-solving is to break down the complexity of a problem in order to focus on knowledge, skills and attitudes which will lead to a solution. There is no formula, routine or recipe for true problem-solving which prescribes exactly how to get from point A to B, else it will not be problem-solving. Problems differ both in complexity and in the nature of skills required to solve them. There are however, models and processes which have been developed in the form of generalised schemes, which might result in progress towards the solution. Some of these generalised schemes are called ***heuristics*** which means "serving to discover" (Nickerson, Perkins & Smith, 1985:74). Heuristics are the powerful tools by which problems may be solved – but are not absolutely guaranteed to work (Martinez, 1998:606). Martinez (1998:606) explains that there are generic and domain specific heuristics. Generic heuristics are cognitive "rules of thumb" which are content free and which can serve to guide the solution of a variety problems. An example of a specific heuristic is to apply the principle of energy conservation in a physics problem.

Algorithms, by contrast are straight forward and recipe like and are guaranteed to work every time. They are step-by-step prescriptions for accomplishing a task (Nickerson, Perkins & Smith, 1985:74). Substituting the numeric values into the formula for determining the volume of a sphere, is an example of using an algorithm.

A few of the general heuristics are mentioned below (Everwijn, Bomers & Knubben, 1993:430, Martinez, 1998:606 and Nickerson, Perkins & Smith, 1985):

- *The problem-solving cycle by **Polya** (1957, 1971).* Polya, who was a mathematician himself, was interested in the teaching of mathematics. The heuristic he described is more generally applicable than to mathematics alone. This heuristic distinguishes four stages:

  - **Understand the problem:** This implies that a problem should be portrayed in an explicit external representation, in order to highlight the main features of the problem, such as the givens, the unknowns, the conditions, the goals state and the permissible operations. This can be accomplished by drawing a graph or a diagram and introducing applicable notation. Important features of this heuristic is that it allows more complexity to be presented than we can hold in the mind at once. The processing capacity of the brain is then not burdened with all the problem details and can be directed to solving the problem.

  - **Devise a plan:** This entails developing a general strategy, not a detailed proof. Formulation of this strategy is according to Polya an inductive one and not a deductive one.

  - **Carry out the plan:** This is the detailed proof and it is at this stage where deductive reasoning plays a role.

  - **Look back:** Results and the different steps used, have to be checked.

- *The "means-ends analysis" or the sub-goal analysis:* This heuristic means 'do something to get a little closer to your solution or goal'. Subsequently sub-goals should be formed which will reduce the discrepancy between the initial state and the ultimate goal. This heuristic assists in incremental advancement towards the ultimate goal, when applied repeatedly. The typical Tower of Hanoi problem is solved using this heuristic.

- *The "working-backwards" heuristic:* This heuristic implies that the ultimate goal should be considered first, and from there onwards a decision should be made about what would be a reasonable step just prior to that goal. This is useful when there are many possible operators and solution paths that could be applied to the initial state, but few that could lead from the last intermediate to the goal state.

- *The "successive approximation" heuristic:* This heuristic solves a problem by initially putting on the table a product that is not totally satisfactory. Over time it will gradually be moulded and polished into shape until the final product approximates the effect initially intended. Writing of manuscripts, a thesis or even creating a work of art primarily make use of this heuristic. Some technological design processes heavily rely on this heuristic.

These are just some of the heuristics which can be used to guide the problem-solving process. A culture to be cultivated by problem-solvers and designers of problem-based learning opportunities is that problem-solving ***by its very nature, involves errors, obstacles, doubt and uncertainty***. We live in times where everything comes in pre-packed quick fix parcels and where errors imply failure. Problem-solving however, implies taking risks, failing, experiencing frustration, demotivation and trying again showing resilience.

Devore (1988) and DeLuca (1992) also describe problem-solving strategies which may be divided into five broad categories. The unique nature and structure of different fields or Learning Areas will affect the way in which the general heuristics or problem-solving strategies are adapted and integrated to address particular problems. The following strategies are well suited for technology and science education. They are the following:

- **The scientific process:** This methodology deals with experimentation and attempts to quantify phenomena into measurable quantities in order to determine or predict **cause** and **effect** relationships. This method has the following procedure:

  - Observe and formulate the problem in such a way that a hypothesis can be formulated.
  - Formulate a hypotheses (H_0).
  - Design an experiment in which all the dependant and independent variables are clearly defined in which the hypothesis can be tested.
  - Select an experimental and control group which can be compared in terms of the predetermined variables. The experimental and control groups can also be compared in terms pre- and post tests.
  - Obtain the data.
  - Analyse the data using empirical-statistical methods.
  - Present the results in some statistical format.
  - Interpret the results.
  - Accept or reject the hypothesis (H_0). Accept an alternative hypotheses (H_1) if one was formulated.
  - Draw conclusions.

- **The design process:** In the field of technology and technology education, this problem-solving process may also be called the **technological process**. In this process learners are presented with a problem which requires that learners design a process, system or product as solution to the problem. Learners will have to generate ideas, suggesting possible solutions, select the most appropriate solution, make prototypes, evaluate and refine their initial design. This process will be elaborated on in Section 3.5.2.1.

- **The research process:** Learners will have to identify or be presented with a situation in which they have to develop an innovative problem solution. They will have to design a research plan, decide on an appropriate methodology, gather, analyse and report data, reach conclusions and evaluate the research project.

- **Project management:** After learners have identified project goals and objectives, they have to identify tasks that will enable the attainment of the goals. Following task identification, they have to develop strategic plans, implement and evaluate the plans.

- **Trouble shooting or debugging:** Here learners are presented with a problem related to equipment or the operation of a system. Learners have to trace the cause of the malfunction by taking measurements, making observations, isolating the problem, implementing correctional procedures and testing it.

Before the discussion can embark on the conceptualisation of the technological process as a problem-solving process, per se, technology as a field or a Learning Area has to be demarcated first. In the pursuit of exploring the nature and structure of technology, it will also become clear why PBL was identified as a strategy for training prospective technology teachers.

The rest of the chapter will focus on how technology and technology education are conceptualised, internationally and nationally.

3.4 What is technology education? Perceptions and definitions.

Existing perceptions of technology are unlimited. Due to the permeating nature of technology in the every day lives of people, a multi-facetted understanding of technology and technology education exists. Some of these understandings include the following:

- The high-tech cyber world of computers, software and electronic equipment.
- Technical-vocational orientated environments.
- Industrial arts, arts and design.
- Applied science and engineering.

It may well be that the collective understanding of technology and technology education is what it actually entails. For the purpose of practising technology education as a science, it is imperative to have a mutual understanding of this terrain, at least as it is conceptualised in South African education.

3.4.1 Defining technology

Herschbach (1995) traces the etymology of the word technology as being “reasoned application” of technical knowledge. He theorises that technology is epistemologically different from formal knowledge of academic disciplines, since it exists through activity. According to him it is the activity-based nature which establishes the framework within which technological knowledge is generated and utilised. Thomas (1988) however, places the "activity" within a broader context of creative human activity which is purposeful. A detailed definition is given by Thomas (1988:12):

> *Technology involves a creative human activity which brings about desired changes by making things, controlling things or making things work better by careful designing, making and evaluation using relevant knowledge and resources.*

Johnson (1989:3) formulates a more concise definition:

> *Technology is the application of knowledge, tools and skills to solve practical problems and extend human capabilities.*

The definition for technology contained in the South African Technology 2005 Draft National Framework Document (Department of Education, 1996b:12) is formulated as follows:

> *Technology is a disciplined process using knowledge, skills and resources to meet human needs and wants by designing, making and evaluating products and processes.*

This definition has a strong focus on the process nature of technology where the mind and hand work interactively. HEDCOM (1996: 28-29) reminds us that historically, technology has been mistakenly conceived as being associated with the acquisition of activity-related, motor skills and computer related activities. Waks (1993:i) suggests that it should be borne in mind that modern technology involves higher order cognitive processes in conjunction with practically based problem-solving activities. The implication of process thinking in technology will be discussed in more detail when technology education is defined in the next section.

3.4.2 Defining technology education in the curriculum

To provide a backdrop for the definition of technology education in the new South African curriculum, the general aims envisaged for technology education, will briefly be introduced. HEDCOM (1996:12) states that the study of technology education should stimulate learners' natural curiosity and interest in the man-made environment. It should enable them to understand and critically engage the challenges that technology presents in their future roles as workers, consumers, citizens and parents in a developing South Africa. The Department of Education (1996b:4) clarifies the role to be played by technology education even further when they state the following:

> *Technology's prime claim to a recognized place in the school curriculum lies in its contribution to the growth and development of individual learners. Both younger and older pupils enjoy taking part in the technological process, which makes the subject appropriate for all school phases as well for gifted and less gifted learners. Young people are entitled to a relevant education which will empower them to a meaningful existence. Technology has an important and specific role to play in achieving this aim.*

This quotation also refers to the scope of technology education in terms of equal opportunities, regardless of ability, race, gender or culture. One of the specific outcomes for the technology Learning Area reads that learners should demonstrate an understanding of how technology might reflect different biases, and create responsible and ethical strategies to address them (Department of Education, 1997a:86).

Inclusion of special education needs

Notwithstanding the existence of special schools in South Africa, regular schools also have to deal with issues of inclusion where learners who are physically and mentally challenged have to be accommodated – also in the delivery of technology education (Reddy, 1995:137). The definition and activities should be broad and flexible enough to enable all learners to participate in technological activities. The variety of routes for achieving technological capability should give all learners, especially those with special needs, the opportunity to experience a wider range of activities than in the more traditional approaches (Rodbard, 1992:124).

One of the benefits of focusing on technological capability for learners with special needs, is that it is creative and has a practical focus as well. The traditional approach of learning a large body of knowledge is replaced by the investigation of needs and opportunities, followed by the chance to make or modify something and then to evaluate the solution. According to Rodbard (1992:123-132) the change in nature and methodology envisaged for technology education spares those with special education needs the laborious academic assimilation of facts and gives more opportunities for their creative and practical talents to develop.

Multi-cultural education

Technology education should be particularly sensitive to the way culture and race issues are incorporated into the curriculum (Eggleston, 1992:64). Cultural diversity is a characteristic feature of life in South Africa. It is important therefore, that both teachers and learners are aware of the cultural diversity pervading modern society in South Africa and how this will be reflected in schools. The teaching of technology education will require perception and sensitivity because the meaning and interpretation of technology can vary significantly across cultures (Somerset Design and Technology Advisory Team, 1992:28). The curriculum should be flexible enough to acknowledge and accommodate indigenous forms of technology.

Gender

Technology education has a role to play in the widespread gender related division of labour. Gender related division of labour is one of the *"most marked and persistent of the patterns that characterize human society"* (Cockburn, 1991:41). Women are clustered into relatively fewer occupations. Men by contrast are engaged in a wider range of activities and there are few from which they are entirely absent. For example, while women constitute about 41% of the economically active population in South Africa, they are still clustered around the "poorly paid" community and social services sectors (The Star, 14 November 1994:10).

In the context of the school, although boys tend to dominate the "making" activities and girls are not given the necessary encouragement to work with construction materials (Benson, 1992a:100), there is no evidence to indicate that overall ability in technology activities is limited by gender variables (Eggleston, 1992:59). Technology should entail activities of equal relevance to girls and in a balanced range of contexts. It is important that teachers guide learners in the choice of technology activities which do not emphasise gender stereotypes (Somerset Design and Technology Advisory Team, 1992:28).

Technology education should give all learners the confidence to address needs and opportunities, solve problems and respond meaningfully to technological change. It should further contribute to the following (Department of Education, 1997a:84-85):

- The development of learners' ability to perform effectively in their changing environment and to stimulate them to contribute towards its improvement.
- The effective use of technological products and systems.
- The ability to evaluate technological products, processes and systems from functional, economic, ethical, social and aesthetic points of view.
- The designing and development of appropriate products, processes or systems to functional, aesthetic and other specifications set either by the learner or others.
- The delivery of quality education and access and redress through (1) relevance to the ever-changing modem world and (2) integration of theory and practice.
- The development of citizens who are innovative, critical, responsible and effective.
- The demystification of technology.

- The recognition of and respect for diverse technological solutions and biases that exist.

- Creating more positive attitudes, perceptions and aspirations toward technology-based careers.

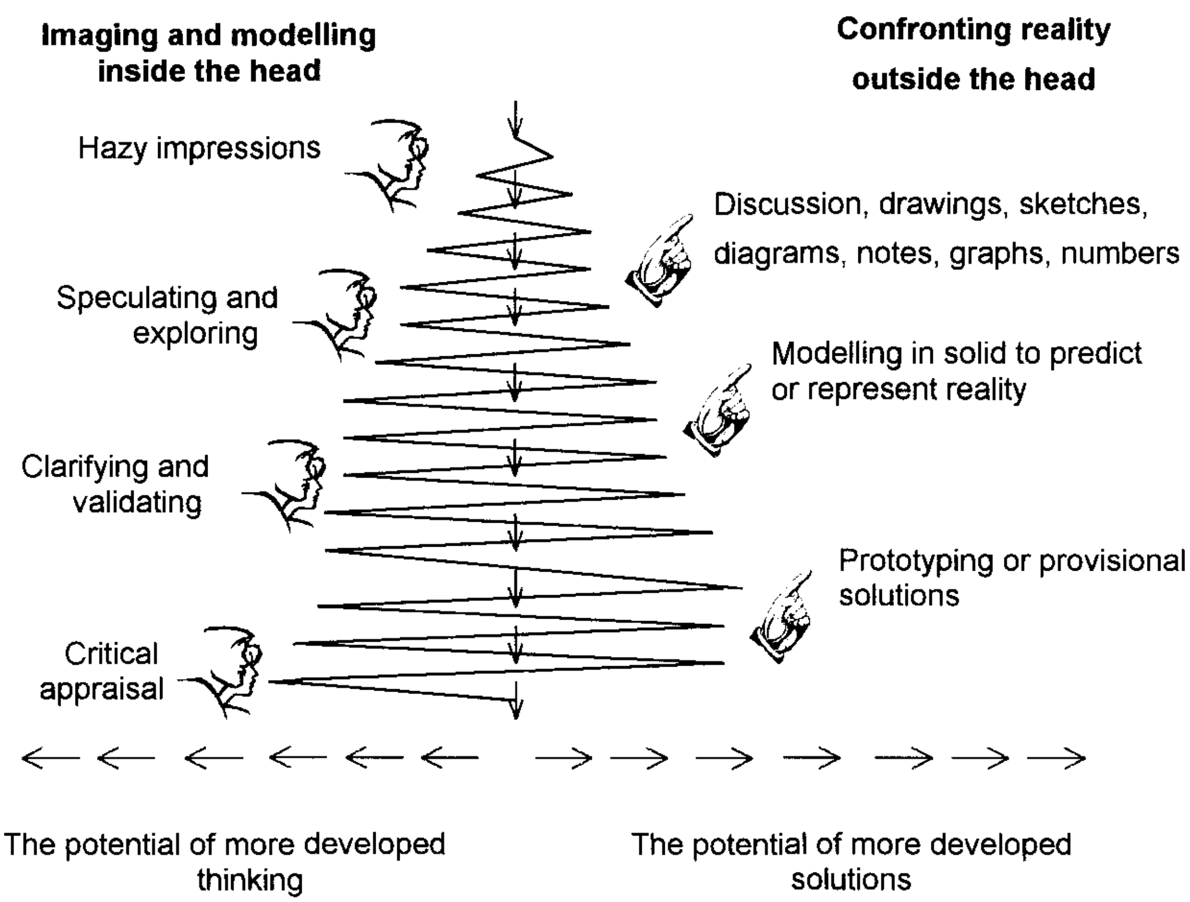
With these aims in mind for technology education, it is clear that technology education should no longer be confused with educational technology and technical education which is presented in technical schools. Technical education, according to Pena (1992:149) focuses on the practical knowledge needed to perform skilled jobs. Its purpose is vocationally orientated and its contents are defined according to the specific tasks to be performed in the workplace. Technology education, however, is none of the above. In different countries, different definitions of technology education exist, depending on their vision and agendas with this Learning Area. In South Africa, the following definition forms the corner stone of this new Learning Area in Curriculum 2005 (Department of Education, 1996b:12-13):

> *Technology education concerns technological knowledge and skills, as well as technological processes, and involves understanding the impact of technology on both the individual and society. It is ultimately designed to promote the capability of and to stimulate him/her to contribute towards its improvement. This capability should be reflected in:*
>
> – the effective use of technological products and systems;
>
> – the ability to evaluate technological products/processes from functional, economic, environmental, ethical, social and aesthetic points of view; and
>
> – the ability to design and build appropriate products to functional, aesthetic specifications set either by the learner or by others.

This definition reflects in itself the **interactive process of thinking and doing**. The why and how is just as important as the what – products, artefacts and systems, which are the results of a process. The technology in which learners have to be educated involves more than conceptual understanding only - but is dependent on it, and it involves more than practical skills only – but is dependent on it (McCormick, Murphy & Harrison, 1992:61). A model called the APU model visually represents the interplay between head and hand as it is intended in the South African technology curriculum. This model also forms a foundation for the technological process, which is the first specific outcome for this Learning Area in Curriculum 2005. The technological process will be attended to in more detail in Section 3.5.2.2.

This model came into existence when a team of the Goldsmith's College in the United Kingdom was commissioned by the Performance Assessment Unit to assess the technological capability of 15 year olds. These learners were exposed to the English and Welsh National Design and Technology curriculum (Stables, 1992:372-375). The strength of this model according to the researchers, is the fact that the interactive process between thinking and doing, remains intact. The thinking and doing modes are not fragmented into thinking on the one hand and final technological products on the other. This is important for assessment in technology education since this model highlights that it cannot only be the technological products which should be assessed but the process as well. This model claims to promote a holistic perception of how technology education should be conceptualised and which the South African definition of technology education also promotes.

Figure 3.2 The APU model of interaction between mind and hand



The left side of the triangle represents the imaging and modelling inside the head, while the right side represents the tangible actions which are the results of the mind actions and which may in turn feed back into the refinement of the mind's idea or speculation. For example, the process of trying to express a hazy idea or solution in the mind, actually forces the learner to clarify the idea. By trying to express ideas in words, pictures or concrete reality, the learner actually gets closer to seeing the difficulties and possibilities within it (McCormick, Murphy & Harrison, 1992:61).

The definition of technology education explained above is derived from the seven specific outcomes for technology education, their assessment criteria and range statements. All the specific outcomes are underpinned by the seven plus five critical outcomes. The relationships between these elements have been explained in detail in Chapter 2, Section 2.4.3. and Section 2.4.3.3. Only the seven specific outcomes will be presented below. The detailed assessment criteria and range statements are included as Appendix 3. The specific outcomes are the following:

SPECIFIC OUTCOME 1: Understand and apply the technological process to solve problems and to satisfy needs and wants.

SPECIFIC OUTCOME 2: Apply a range of technological knowledge and skills ethically and responsibly.

SPECIFIC OUTCOME 3: Access, process and use data for technological purposes.

SPECIFIC OUTCOME 4: Select and evaluate products and systems.

SPECIFIC OUTCOME 5: Demonstrate an understanding of how different societies create and adapt technological solutions to particular problems.

SPECIFIC OUTCOME 6: Learners will demonstrate an understanding of the impact of technology.

SPECIFIC OUTCOME 7: Learners will demonstrate an understanding of how technology might reflect different biases and create responsible and ethical strategies to address them.

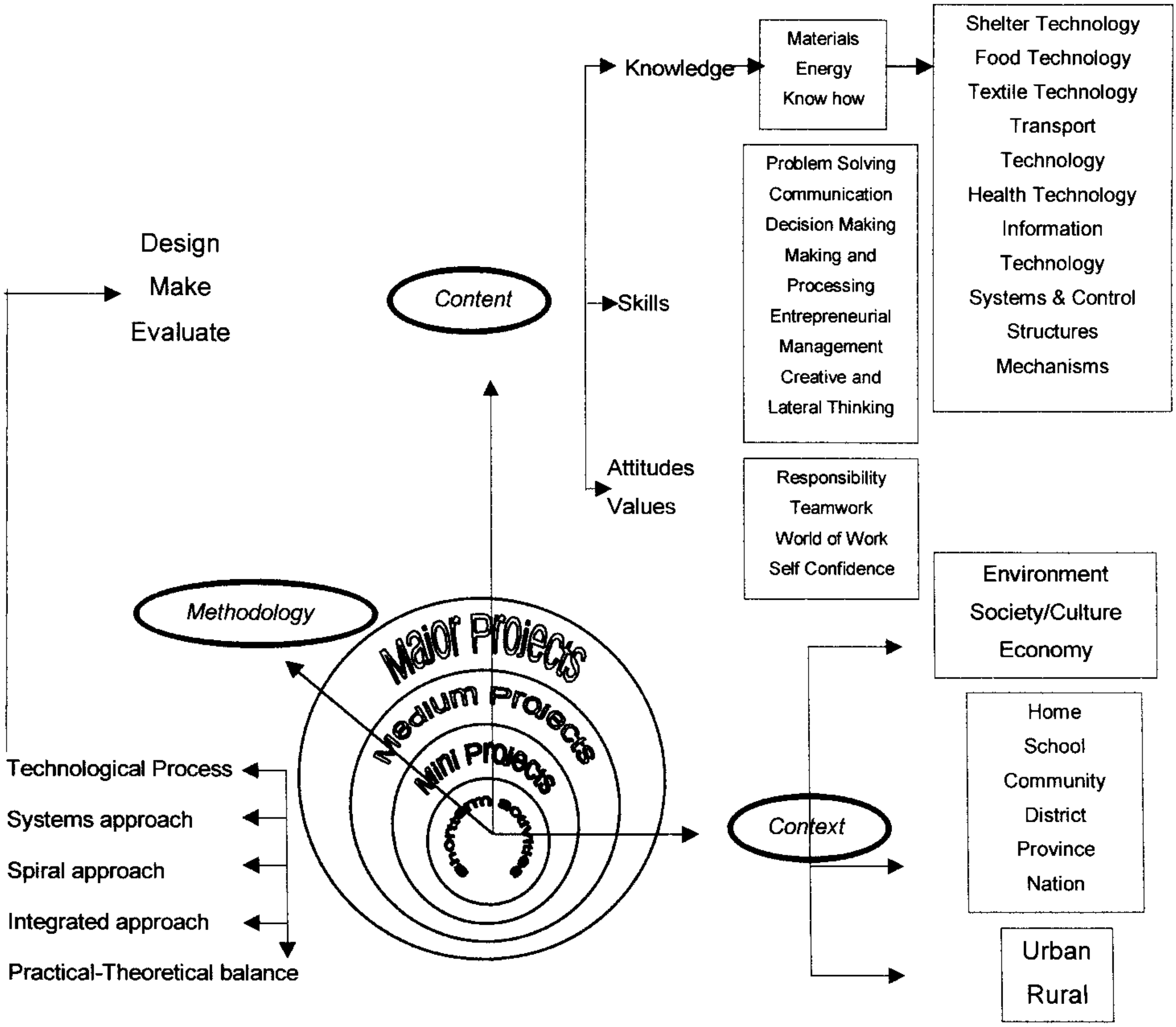
The specific content for the technology curriculum, which is also briefly outlined as part of the range statements, will be divided into a specialist and general dimension. The specialist dimensions comprise of the following broad groupings of concepts and skills (HEDCOM, 1996:13 and Department of Education, 1997a:93):

- Systems and control (Mechanisms, Electrical, Hydraulic and Pneumatics).
- Structures.
- Communication.
- Processing (Food, Textiles and other materials).

These specialist dimensions will form a basis upon which specialisation in the Further Education and Training Band can take place in technology education. In addition to the specialist dimensions are the **general dimensions** which are energy and power; materials and components; information and safety.

Although it was not initially intended this way, a model by Eisenberg (1992) representing the characteristic features of technology education provides a comprehensive overview of the curriculum framework for technology education as it has been taken up in the South African curriculum. In Figure 3.3 the three different axes showing methodology, content and contexts, represent the specific outcomes, assessment criteria and range statements specified in Curriculum 2005. What Eisenberg calls methodology does not imply teaching methodology, but methodologies associated with the processes of technology, which where formulated as specific outcomes in Curriculum 2005. The content axis includes other specific outcomes for technology education, as well as the specialist and general dimensions of content. The context axis is representative of the range statements which provide the detail of the contexts in which outcomes have to be demonstrated.

Figure 3.3: Eisenberg (1992) model representing the characteristic features of technology education



These dimensions represent understandings, knowledge and skills around which the technological process and learning opportunities can be designed. The idea with these dimensions is not to compartmentalise technology. As technology problems and projects become more complex and sophisticated, they should be integrated in a realistic range of ways. The general dimension "safety" for example, must be integrated in each of the other dimensions.

3.5 The nature and structure of technology education

Within the innate nature and structure of a discipline lie the foundations for an appropriate teaching methodology. The substantive structure of a discipline represents the "what" of a discipline, while the syntactical structure is representative of the "how". The syntactical structure provides the mechanisms and processes for generating new knowledge - the "what".

The following paragraphs will explore the nature and structure of this rather new field of study, which will then provide background knowledge when exploring appropriate methodologies and strategies for the training of pre-service technology teachers.

3.5.1 The synergy between mathematics, science and technology – a cross-disciplinary nature

Often technology is perceived as applied science, using mathematics as a language for expressing its manipulation of the material world in terms of its measurements. The disciplines of science and technology are often combined in a phrase "science and technology" as though they connote a single entity. A White Paper on 'Science and Technology' exists, and 1998 was the Year of "Science and Technology" in South Africa. Much has been written about the independence of science and technology as well as about their inter-dependence. The fact that science is always mentioned first might presuppose that science is logically prior to technology. However, science always preceding technology is not necessarily the truth when history is studied. The use of levers existed long before mechanics were described in terms of laws of mechanics, using mathematical formulae

(HEDCOM, 1996:26).

During the Renaissance the scientific method of empirical verification liberated humanity from superstition and opened new gateways to controlling the natural world. This resulted in the Industrial Era where machines were extending and replacing the work done by human hands. From there onwards the century has witnessed exponential growth in the manmade technological environment.

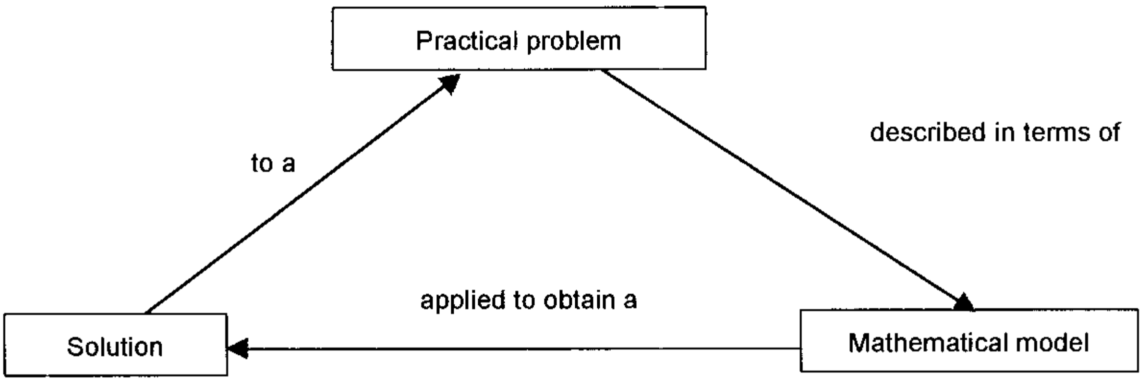
It would seem then that the differences between these two disciplines are to be found in the purpose of the activities involved, while the affinities reside in the practices. Unesco (1983:17-18) states that the purpose of science is to enlighten humanity by building up knowledge: to give an explanation of something, to provide a true description of some event or to diagnose the nature of some condition. The purpose of technology is to facilitate human aspiration and to serve humanity: to solve some practical problem, to put knowledge to good use and to extend the boundaries of existing possibilities. Thus, while technology draws upon scientific knowledge, it is also concerned with design, with considerations of social and legal issues, as well as costs and feasibility. While science will explain why air which moves rapidly over a surface exerts less pressure on that surface than slow moving air, technology will attempt to use this knowledge to make a machine that will fly.

At the JISTEC 1996 Conference held in Jerusalem on science and technology education, the differences between science and technology were illustrated as follows (Department of Education, 1996b:26):

SCIENCE	TECHNOLOGY
Curiosity-driven	Need or want-driven
Aim is to explore natural phenomena and reach ever improving understanding	Aim is to design and develop new products which solve new or existing problems
Works with idealised models of the world, based on certain assumptions	Works in the real, complex, human world
Internal criteria are truth, accuracy and the ideal	Criteria are solutions which are effective, efficient and within acceptable tolerances and

	standards
Looks for universal knowledge	Looks for optimal solutions for specific situations

Both science and technology are also related to mathematics. Mathematics plays a fundamental role describing problems and needs of the environment. It also plays a central role in the description of generalised and rigorous science theories, underlying technological innovations. When dealing with problems and needs it becomes necessary to investigate, collect, analyse, and communicate the quantitative data. This is usually done by using mathematical modeling, shown in the diagram below (HEDCOM, 1996:27):



After a practical problem has been modelled mathematically, the solution is obtained by using the appropriate techniques, sets of equations and formulae, to present a solution in some format or another. Mathematics thus becomes a vehicle for contributing towards a more theoretical, rigorous science as well as the solution to the problem. While developing an arithmetical system which uses just one symbol and a placeholder, instead of nine symbols and a place holder is a mathematical activity, using such a system to design a computer, is a technological activity. Furthermore, mathematics is used to estimate, compute, measure, predict and to scale in technology (Raat, 1992:362).

In schools in different countries the synergy between these subjects is acknowledged in different ways. The traditional curriculum in different countries caters intentionally for science and mathematics, while this is not the case for technology. Only in very recent years have a small number of countries taken technology education up in their curricula. Chapter 1 Section 1.3.1 gives a full account of various models which were used to accommodate technology education in their schools. In the Netherlands for example, the synergy between science and technology has been accommodated in three different ways in secondary education. Firstly, technological topics have been incorporated into the existing science curriculum. Secondly, a new curriculum called Science, Technology and Society (STS) has been introduced or added to existing science curricula. The third option was the introduction of technology as a separate curriculum (Eijkenhof, Franssen & Houtveen, 1998:667). Each of the options had its advantages and disadvantages in terms of competition between science and technology teachers, the lack of competent teachers in both areas, the different teaching methodologies associated with science and technology, etcetera (Eijkelhof, Franssen & Houtveen, 1998:688-689).

In Ontario, Canada, the curriculum innovation has gone beyond only integrating the mathematics, science and technology curriculum. They integrated the 'maths, science and technology' Learning Area also with Learning Areas such as arts, language and self-and-society. They organised the Learning Areas around broad themes or topics which were being dealt with in different Learning Areas at the same time (Black & Atkin, 1996:46). In Australia, science and technology are combined in the primary school, but separated in the secondary school. In the secondary school the Learning Area is actually called Technology and Applied Studies and it contains a subject called Design and Technology that is compulsory during the first two years of high school (Morgan, 1992:133-134). The debate of which implementation models will be most beneficial to learners in South Africa, is only in its beginning stages of research and will not be discussed further in this literature survey.

In South Africa, it was mentioned earlier that technology is part of the general science curriculum in the foundation, and intermediate phase in Curriculum 2005, while it will be treated as a separate Learning Area in the senior phase. Technology is compulsory in all of these phases. For the further education and training band (FET), it can only be speculated that technology will not be a fundamental or core subject, but a separate elective subject, which might offer dimensions for specialisation (Department of Education, 1997d:49).

However, current research proposed that the compulsory core Learning Areas in the FET phase should include science, technology, social sciences, a work related area and citizenship (Department of Education, 1997d:50).

Although technology has strong cross-curricular relations with mathematics and science, it is not the only cross-curricular relationship that exists. Several authors, notably Dacey (1986:19), Young (1991: 236-237) Benson (1992a:8) and Raat (1992:362) agree about the inter-disciplinary nature of technology education. They have identified the following few examples, apart from mathematics and science, which display this cross-curricular connection:

- From **Industrial Arts** and handicraft, technology education draws on the knowledge of (1) materials and the way they can be worked (2) tools, their use and safety (3) aesthetic and ergonomic factors.

- From **Home Economics** it draws on (1) experience of working with materials associated with food and textiles (2) experience of packaging, presentation and nutritional value of food (3) knowledge of dyeing, weaving and packaging of textiles.

- From **Business Economics** it draws on (1) knowledge of business and economic awareness (2) entrepreneurship.

- From **Economics** it draws on (1) considerations on the availability of materials (2) considerations of the costs of materials, the processes used and the time taken to complete a task.

- From **Technical Drawing** it draws on (1) knowledge and drawings of two and three dimensional shapes (2) spatial awareness.

- From **Art** it draws on how technology cannot only meet the technical needs of people, but also their aesthetic needs.

With the understanding of the inter-disciplinary and cross-curricular nature of technology education, we can proceed to another characteristic feature in the nature and structure of technology education.

3.5.2 The problem-based nature of technology education

In the previous section it was seen that science and technology are inter-dependent but contrasting activities. The one undeniable characteristic of technology is its need-driven and problem-orientated nature (Pucel 1992, Johnsey, 1995 and Williams & Williams, 1997). Technologies being used to address problems in turn create new problems such as pollution, health hazards, job displacement and others. Although technology contributes to new types of problems, technology will be used to address possible solutions to the problems it created (DeLuca, 1992:26).

In the technological endeavour to solve a problem or need, technology draws not only on scientific knowledge, but also concerns itself with social, environmental, legal and economical issues. Real life problems never exist in isolation, but draw on a variety of resources from different areas. It seems then that successful technological activities are integrated and multi-disciplinary. The implication of this for education is that it has natural links to most of the other curriculum Learning Areas: language, communication, social studies, arts, humanities, environmental studies and technical studies. Technology education brings down the artificial boundaries between subjects (HEDCOM, 1996:4). Technology, with its focus on real life problems, can motivate learners to learn science, mathematics and other subjects, since it makes these Learning Areas relevant for real life.

To seek solutions for real life problems, the solvers need to embark on a journey of problem-solving processes. In Section 3.3.9 problem-solving in general was addressed. The typical mode of thought of a technologist is lateral, implying that scientific materials and knowledge have to be used in a creative, inventive but responsible ways – 'this' does not work, lets try "that". This does not mean that the technologist will not need the typical mode of thought of the scientist, which is longitudinal, meaning that the principle of causality is adhered to – "this" logically follows "that" (Unesco, 1983:18).

The first specific outcome for technology education in Curriculum 2005 (Department of Education, 1997a:84), links problem-solving for technological purposes directly with the technological process:

> *Understand and apply the technological process to solve problems and satisfy needs and wants.*

In different technology education curricula the technological process is often mentioned in conjunction with the concept "design". In the United Kingdom the new Learning Area is called Design and Technology (Johnsey, 1995:199). In Australia, Design and Technology is one of the subjects resorting under the Learning Area Technology and Applied Studies, as was mentioned earlier as well. Often in the literature "design", "the technological process" and "solving open-ended problems" are used interchangeably. In the aforementioned paragraph the design process was proposed by Devore (1988:2) as a problem-solving process with the following stages:

- Ideation/Brainstorming
- Identify possible solution
- Prototype
- Finalise design

Johnsey (1995:199) explains that the process followed to achieve a solution to a open-ended problem, is called a problem-solving process. Once the problem-solving process is executed to fulfil a need or want, it is called the design process.

Design, however can also be interpreted in different ways. Often it is used to refer only to the planning of a product or system in terms of a drawing or diagram. Sometimes it is used in its broadest sense to include the planning phase, making, testing and evaluation. In this research the term 'technological process' will be used when the broadest sense of design is referred to.

The following paragraphs will attempt to give an in-depth understanding of the technological process. The main reason for analysing the constituent phases in the technological process lies in the need to make it possible to teach and assess it (Kimbell, 1994:19). This will be done by giving an overview of different models for the technological process.

The overview will start by giving in table format the processes associated with different models. The models referred to in the table were models that developed over a period form 1971 to 1995 in the National Curriculum of England and Wales (Johnsey, 1995:208). It provides a useful overview of the similarities between various design processes. The table will present the general processes in linear form while in the original presentation they might be circular or have other diagrammatic formats. Different process skills which emerged as common denominators in the different models will be listed in the left hand column. These skills are the following: **Identifying; clarifying; specifying; researching; generating; selecting; modelling; planning; making; testing; evaluating; selling** (only present in one model).

Table 3.2: Models of the design/problem-solving process (*Johnsey, 1995*).

Process skill	1 Design and craft education project, Design for Today (1971)	2 Understanding design and technology, Assessment of Performance Unit (1981)	3 Craft, design and technology from 5 to 16, Department of Education and Sciences for England and Wales (1987)	4 APU Design and Technological Activity – A framework for assessment, (1987)	5 The assessment of performance in Design and Technology. Kimbell (1991)	6 Design and Technology in the National Curriculum (Key Stage 1), (1995)
Identifying	Identify problem area. Identification of needs from given set of circumstances observations resulting in design brief.	Recognising the existence of a problem which might be amenable to solution through D&T activity.	Recognise the general problem area.		Hazy impressions inside head.	... generate ideas
Clarifying	Identification of control factors. Imposition of control factors.	Employing knowledge, analysis, skills and judgement in clarifying the problem.	Specify the exact need. Write the brief	Speculating in the mind's eye together with informal sketch-drawing and modelling.		... clarify their ideas
Specifying	Specification. Translation of design problem into appropriate terms.	Matching the proposed product with its purpose.	Write 'the specification'.			

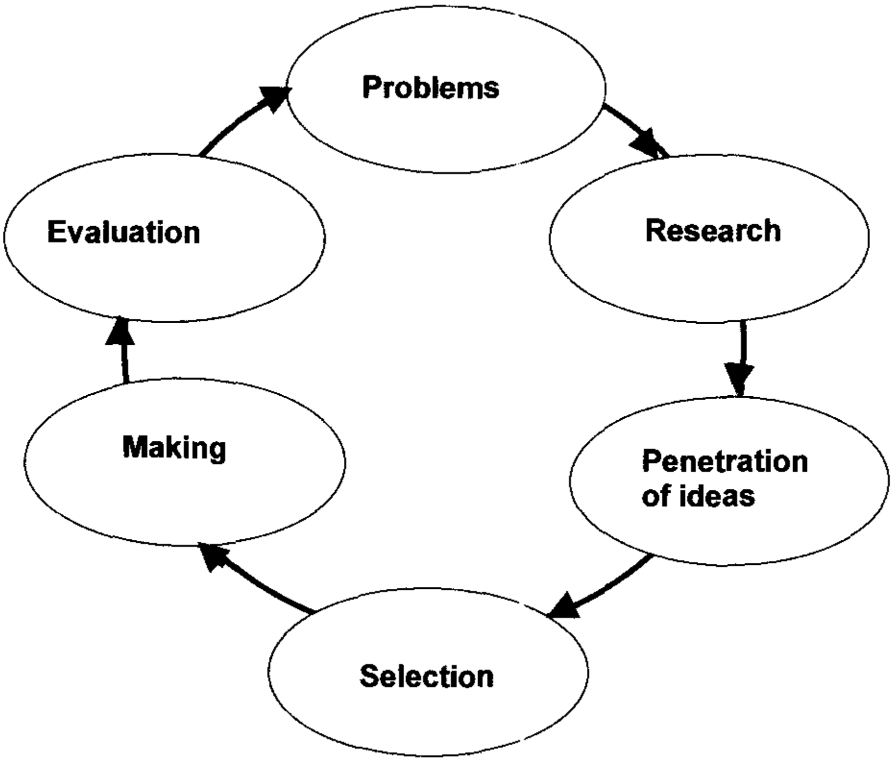
Researching	Gathering of specific information related to problem.	Looking for relevant information and resources.	Research. Collect data.			
Generating	Production of outline solutions.	Thinking of alternative solutions.	Generate ideas and share thoughts with other helpful agencies.			
Selecting	Selection from possible alternatives.	Choosing the best from these.	Select and formulate the design proposals.	Exploring and developing ideas inside the head.	Discussion, drawings, sketches, diagrams, notes, graphs, numbers outside head. Speculating exploring inside head.	
Modelling	Foundation work through "soft" materials, i.e. card, clay etc. Production of models.	Initiating and developing ideas and images and manipulating those images modelling these images in a variety of ways.	Model ideas and test them.	More formalised sketching drawing and experimental modelling.	Modelling in solid to predict or represent reality outside head.	...develop ideas through shaping, assembling and rearranging materials ... ... develop and communicate ideas by modelling ...

Planning		Planning the practical activity. Selecting resources.	Detail intentions and plan manufacture. Relate the methods of making to the facilities and resources available, making any necessary adjustments.			... make suggestions about how to proceed ... select materials, tools and techniques.
Making	Consolidation of workable solutions towards realisation.	Using tools, instru-ments, materials, components, appliances and energy resources.	Make the solution, refining the proposal as necessary.	Refining and detailing in the head together with prototyping	Prototyping or providing solutions outside head.	... measure, mark out, cut, shape, assemble, join and combine a range of materials .... apply simple finishing techniques.
Testing	Judgements and decisions.	Testing the performance of a given product.	Test the outcome.	Validating and judging inside the head together with testing.	.	
Modifying			Adjust if possible.	Modifying		

Evaluating	Assessment of goal achievement. Judgement of the solution in terms of the brief and the specification.	Monitoring effects of operations controlling outcomes understand-ing context in which product to be used; identifying the criteria by which it should be judged: choosing measures; forming judgements; distinguishing needs assigning priorities; appraising efficacy and design activity.	Evaluate the outcome against the original need.		Critical appraisal inside head	. . . consider design ideas as these develop and identify strengths and weaknesses . . . evaluate their products, identifying strengths and weaknesses.
Selling			'Sale and use'.			

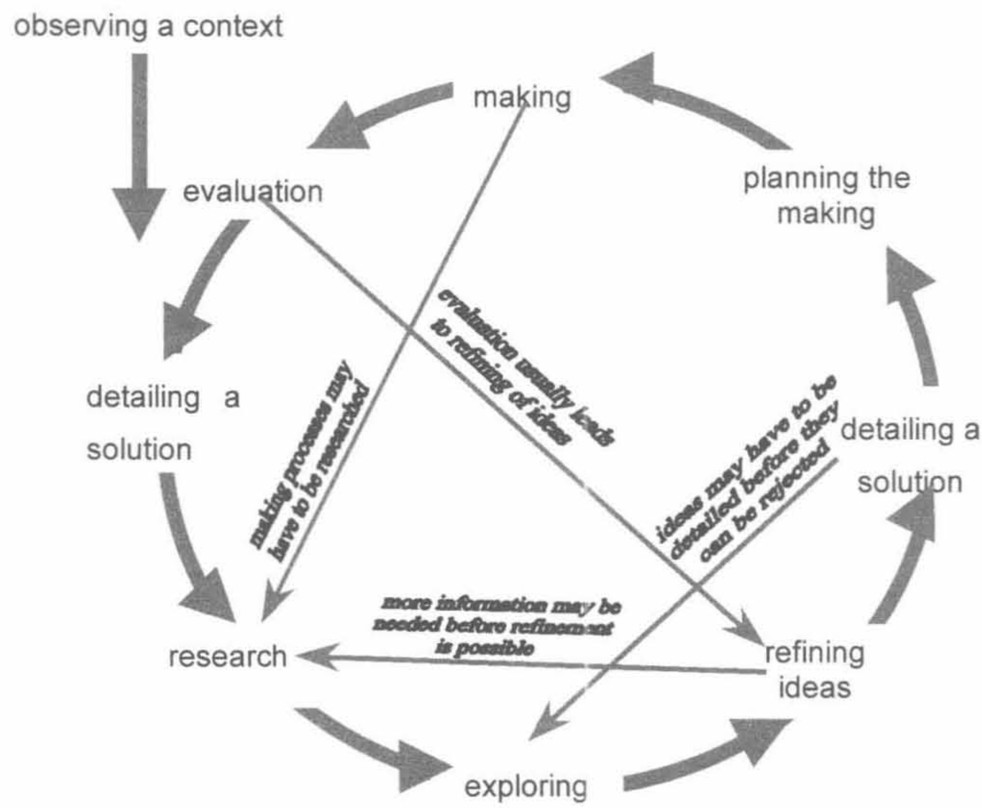
A circular representation of different stages in the technological process may be depicted as follows (Williams & Williams, 1997:91):

Figure 3.4: An example of a technological design model



Although these models are helpful guides as to what sorts of activities need to go on in the technological process, they can cause misinterpretations in terms of the sequential stages to be followed in the process. The research or investigation stage for example, does not have to be executed only in the beginning of the technological process, but while making the product as well. Learners actually need to be investigative throughout the different processes (McCormick, Murphy & Harrison, 1992:60). Kimbell (McCormick, Murphy & Harrison, 1992:60 and Williams & Williams, 1997:95) suggests an interactive design loop for the technological process where different stages are linked in the following way:

Figure 3.5: An example of a technological design model



(Cuthbertson, 1990:191)

The overview provided in both table and diagrammatic format, illustrates that differences exist among these models, but that the general stages and processes associated with them are actually similar. The literature, however, gives a cautionary note regarding displaying the design process as a fixed, simplistic linear or cyclical process. Baynes (1992:1) makes it clear that

> *the processes involved in designing are not linear, they do not always start from human needs, and they do not always proceed in an orderly way. They are iterative, spiralling back on themselves, proceeding by incremental change and occasional flashes of light.*

Furthermore it is argued by Hennessy & McCormick (1994) that problem-solving used either by novice problem-solvers or expert problem-solvers depends heavily and is strongly influenced by the **context** of the design. In other words all problems and needs to be addressed are not alike and the research approach (dissection, fact gathering, testing and selecting) is not applicable to all situations. Flowers (1998:21) mentions that few of today's technological products are actually designed to meet actual needs. They are almost always designed for open markets and only then are human wants engineered around the product availability, using the science of effective marketing.

Flowers (1998:20) advocates another avenue of problem-solving all together in technology education, which is a departure from the western (or stereotypical male) approach to technology. Western definitions accentuate that the goal of technology is to gain control over the environment to meet human needs and wants. Flowers (1998:220) suggests that technology education should accommodate different belief systems. He explores the Taoist philosophy translated by Lao Tsu (1972) from the Tao Te Ching document in the 6th Century BC China. He identifies some principles from the document which may be considered when teaching technological problem-solving.

Although bias against the Taoist doctrines may exist, a few of the doctrines which have meaning for technology education will be discussed. Doctrine 46 states "*who knows that enough is enough will always have enough*". One "*who is attracted to things will suffer much*" (doctrine 44). "*One gains by losing and loses by gaining*" (doctrine 42). This implies that the technology learner should be sensitised that the best solution to a problem may be non-action and acceptance of a situation or system without change. This means that technology learners should use their problem-solving skills to improve the human and also the non-human condition, in spite of what some people think they need or want (Flowers, 1998:13).

The implication for technology education is that different belief systems, cultures and their concurrent models should rather be viewed as frameworks for the technological process which should maintain the necessary flexibility to be modified as required by a specific problem context or need.

3.5.2.1 The technological process used in South African curricula

The technological process referred to in the first specific outcome for technology education in Curriculum 2005 refers to a cycle of investigating problems, needs and wants, as well as the designing, developing and evaluating of solutions in the form of products and systems. This process is the basis of all technological endeavour. Understanding the process is fundamental to the acquisition of technological literacy (Department of Education, 1997a:86). The technological process is an integrated and indivisible one and therefore, assessment should apply to the whole process. This integrated notion of assessing process and products is in line with the assessment theory and practices promoted by the inter-active APU assessment model which was addressed in Section 3.4.2. This process is represented in more detail in the following table (Department of Education, 1997a:86 and De Swardt & Ankiewicz, 1996:30-31):

Table 3.3: The technological process as conceptualised in South African curricula

THE TECHNOLOGICAL PROCESS	
NEEDS ANALYSIS AND DESCRIPTION	• identifying a need or problem • writing a design brief • analysing the problem • drawing up specifications
DESIGN AND DEVELOPMENT	• doing research • generating ideas • developing ideas and selecting the best ideas • communicating your idea

PLANNING AND MAKING	• planning: – choosing material, equipment and processes – working out costs – making a working drawing • making: – quality of construction – accuracy – finishing – appearance – safety
TESTING AND EVALUATING	• testing • evaluating
RECORDING, COMMUNICATING	• portfolio to be completed • displaying

This process shows strong resemblance with the design models which were presented earlier in Section 3.5.2. Technology teachers are challenged to teach the technological process both as an end, but also as a means of learning technological content and using that to solve problems.

3.6 Appropriate methodology for facilitating learning in technology education

An appropriate teaching methodology for facilitating the technological process can be deduced from the syntactical structure of technology. *Cognisance should be taken of the fact that the methodology suggested for teaching technology is similar to the methodology advocated by OBE.* To present a methodology for facilitating learning in technology in detail, will be the same as repeating the strategies and methods which would operationalise the principles of an OBE approach in practice. In conclusion the main common denominators in technology and OBE methodology will briefly be highlighted below:

- The methodology of both are based on principles of learner-centredness in its broadest sense. These principles and their meaning for planning and facilitating learning were described in detail in Section 3.2.1.

- Both methodologies value and promote creative problem-solving while critically showing responsibility towards environments, society and the health of others. This characteristic directly acknowledges SAQA critical outcomes number one and six. See Section 2.4.3.2 for the SAQA critical outcomes.

- Problems to be solved should be relevant and authentic. Section 3.3.8.1 provided the criteria for appropriate problems.

- Knowledge and skills are valued equally important for effectively solving problems and performing real life roles.

- Both methodologies draw on and promote cross-curricular problem-solving and learning experiences.

It was the purpose of this chapter to describe and propose PBL as a curriculum model, methodology and strategy for the following various reasons:

- To operationalise the philosophy and principles of OBE in classroom practice and pre-service training programmes.

- To describe PBL as an appropriate methodology for facilitating learning in technology education.

- To describe and design a PBL model which can be used in the pre-service training of teachers who will have to facilitate this new Learning Area also through a PBL methodology. The designed model will be called the OBE-PBL model and will be presented in the next section.

In the qualitative component of this research where the pre-service teachers were interviewed, valuable information is given regarding how teaching technology through PBL has clarified the conceptualisation of outcomes-based principles.

Although the OBE-PBL methodology had been explored intensively in this chapter, it is never the less valuable to take cognisance of the HEDCOM Technology 2005 Project suggestions which need to be considered for technology teacher training programmes. Some are very generic and coincide with roles and competencies described in the Norms and Standards for all Educators which were given in Section 3.2.2. They (HEDCOM) are adamant that technology teacher training programmes should ensure that prospective technology teachers should demonstrates the following competencies regarding methodology (1996:9-13):

- Facilitate learner-centred classroom practice by employing a range of teaching strategies appropriate to technology education.

- Employ methods which encourage the child to engage in creative and innovative activities.

- Employ methods which will develop skills in problem-solving.

- Select and use in a considered way a variety of resources, including information technology.

- Make use of cross-curricular concerns within subject related teaching.

- Create learning contexts in which there is a paradigm shift in emphasis from teacher initiated and determined activities to ones in which learners are encouraged to reflect and to make their own critical choices.

- Develop the skills of technology education.

- Encourage and challenge learners to take initiatives and become responsible for their own learning.
- Develop learning environments that will develop learners' ability to use knowledge, skills and resources to:
  - design solutions to technological problems and needs
  - work collaboratively in groups
  - plan, manage and assess their own activities
  - integrate thinking and action within the context of technological solving
  - make their own decision, to justify choices made and to do self assessment.

- Link school work with authentic technological activities in the wider community.

Project work should therefore form the basis for facilitating learning in technology education (Department of Education, 1997a:84-106 and HEDCOM, 1996:14). Project work can be made up, but does not necessarily have to be, of a combination of case study tasks, resource tasks and capability tasks.

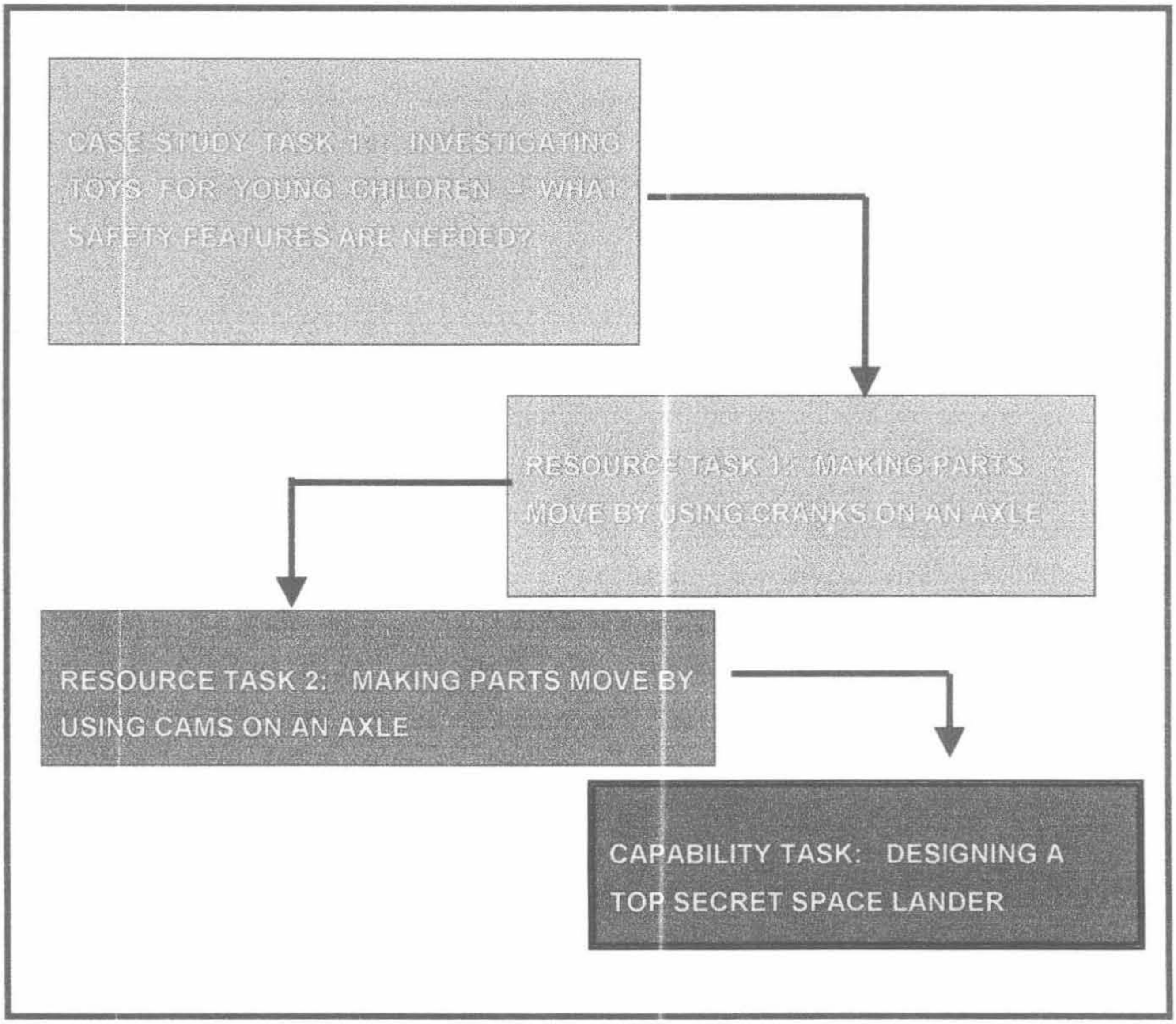
Case study tasks are generally short, structured tasks which aim to link learning in schools with technological experience in the wider community where the community includes post offices, power stations, factories, farms, etc. They should provide a vehicle for examining the ethical, social and environmental issues related to the development of technology and its application.

Resource tasks are generally short-term, structured tasks which aim to develop learners' resources of technological knowledge and skill. An example of a specific skill which learners might need to demonstrate before designing and making a technological device, is how to make a linkage, the mechanism for connecting levers. These tasks may nevertheless include some elements of design and problem solving.

Capability tasks are extended, open-ended tasks in which learners are required to use a range of resources (including the knowledge and skill acquired in earlier activities) to design, realise and evaluate solutions to technological problems. These tasks represent the authentic problem or need which is to be addressed. This is the typical type of problem which was described as the problems to be designed in a PBL approach.

The following figure shows how these three types of tasks may be connected:

Figure 3.6: Project work in technology education (Combining case study, resource and capability tasks to form complete projects: an example from grade 4)

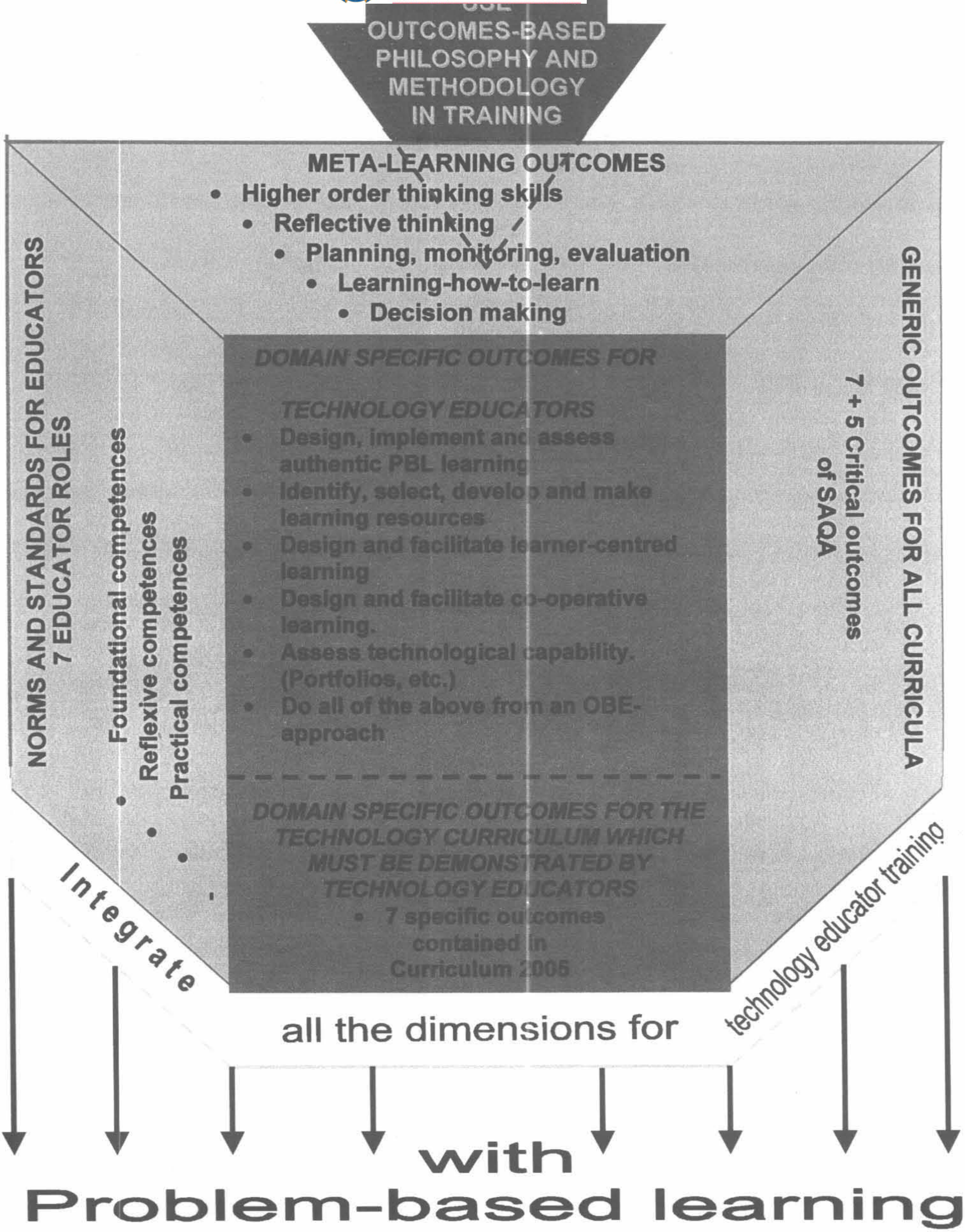


Any teacher training initiatives for prospective South African technology educators should accommodate these lines of thinking in their professional preparation programmes. In the section to follow, the OBE-PBL model will be presented.

3.7 The OBE-PBL model

From the literature on OBE, PBL and technology education which was reviewed in this chapter, a model can be designed as the collective outcome of this chapter for the purposes of this research. The proposed model will be titled the OBE-PBL model, since PBL is hypothesised to operationalise OBE in the training of pre-service technology educators in such a way that they can successfully transfer their competencies to the real job. This model will serve as a meta-curriculum model and not as a blueprint for a pre-service technology teachers' training programme. It highlights the declarative (know-what) and the procedural (know-how) competencies (Everwijn, Bomers & Knubben, 1993:433), which need to be integrated into contextual demonstration (outcomes) during training and classroom interactions through PBL. Figure 3.7 represents the OBE-PBL model.

Figure 3.7: The OBE-PBL pre-service technology teachers' training model


USE
OUTCOMES-BASED
PHILOSOPHY AND
METHODOLOGY
IN TRAINING
META-LEARNING OUTCOMES
• Higher order thinking skills
• Reflective thinking
• Planning, monitoring, evaluation
• Learning-how-to-learn
• Decision making
NORMS AND STANDARDS FOR EDUCATORS
7 EDUCATOR ROLES
• Foundational competences
• Reflexive competences
• Practical competences
DOMAIN SPECIFIC OUTCOMES FOR
TECHNOLOGY EDUCATORS
• Design, implement and assess authentic PBL learning
• Identify, select, develop and make learning resources
• Design and facilitate learner-centred learning
• Design and facilitate co-operative learning.
• Assess technological capability. (Portfolios, etc.)
• Do all of the above from an OBE-approach
DOMAIN SPECIFIC OUTCOMES FOR THE TECHNOLOGY CURRICULUM WHICH MUST BE DEMONSTRATED BY TECHNOLOGY EDUCATORS
• 7 specific outcomes contained in Curriculum 2005
GENERIC OUTCOMES FOR ALL CURRICULA
7 + 5 Critical outcomes of SAQA
Integrate
all the dimensions for
technology educator training
with
Problem-based learning

The first dimension of this model acknowledges the starting point of design of all future curricula and learning programmes in South Africa. This dimension is represented by the right façade of the model and refers to the seven plus five critical outcomes proposed by SAQA – the real life roles which have to realise the vision of lifelong learning of the NQF. Reinforcing the critical outcomes, are the competencies which promote self-directed and reflective learning. These are the meta-cognitive skills, without which a learner or professional teacher cannot do effective action research to enhance their practice performance. These are represented by the top façade of the OBE-PBL model.

The left façade of the model acknowledges the seven educator roles as described by the Norms and Standards for Educators (Department of Education, 2000a). These roles should be taught in an embedded, integrated approach if teachers have to transfer these roles to real life classrooms. The middle façade is separated into two sections. The one deals particularly with the specialist role of being a technology teacher. That means that a teacher of technology education must know the content and processes of the Learning Area. The second part deals with the methodology particularly related to the nature and structure of technology education. This implies, according to this research, that a pre-service teacher must become competent in the design of PBL learning environments and the use of the PBL strategy.

For the pre-service teachers to practise and demonstrate the outcomes in the OBE-PBL model in and integrated way, the PBL strategy was used in their training. After their training period of six months, the pre-service teachers had to operationalise the OBE-PBL model in real classrooms. This means that they had to facilitate learning in technology education through the PBL strategy.

3.8 Summary

Since OBE was described as a philosophy and system for housing the OBE philosophy in Chapter 2, this chapter has mainly started off by focusing on the practical actions that need to be implemented to operationalise the OBE theory in teaching and training practice. One of the strategies which was studied in detail since it showed tremendous potential to operationalise OBE, was problem-based learning. On the other hand PBL as a strategy for training future technology educators was also explored and selected since similarities exist between the nature and structure of this new Learning Area and PBL. The nature and structure of technology education was the primary focus of the last part of this chapter. While discussing the nature and structure of technology education, the similarities between technology education and PBL were highlighted and clarified.

This intensive literature review on OBE, PBL and technology education was undertaken to clarify the main curriculum dimensions which need to be considered when developing a curriculum for the training of prospective technology teachers who have to work from an OBE perspective. The OBE-PBL model was designed as a meta-curriculum model and was used as the training model for the pre-service teachers. This is the model that the pre-service teachers had to internalise to such an extent that they could transfer the outcomes entailed in the model to the real context.

The next chapter will describe the PBL training interventions in the university classrooms, as well as the pre-service teachers' interventions with the pre- and post-groups in real classrooms. The instrumentation which was used to get information on the extent of competency transfer by the pre-service teachers will also be a point of focus.

CHAPTER 4

RESEARCH DESIGN, METHODOLOGY AND INTERVENTIONS

4.1 Introduction

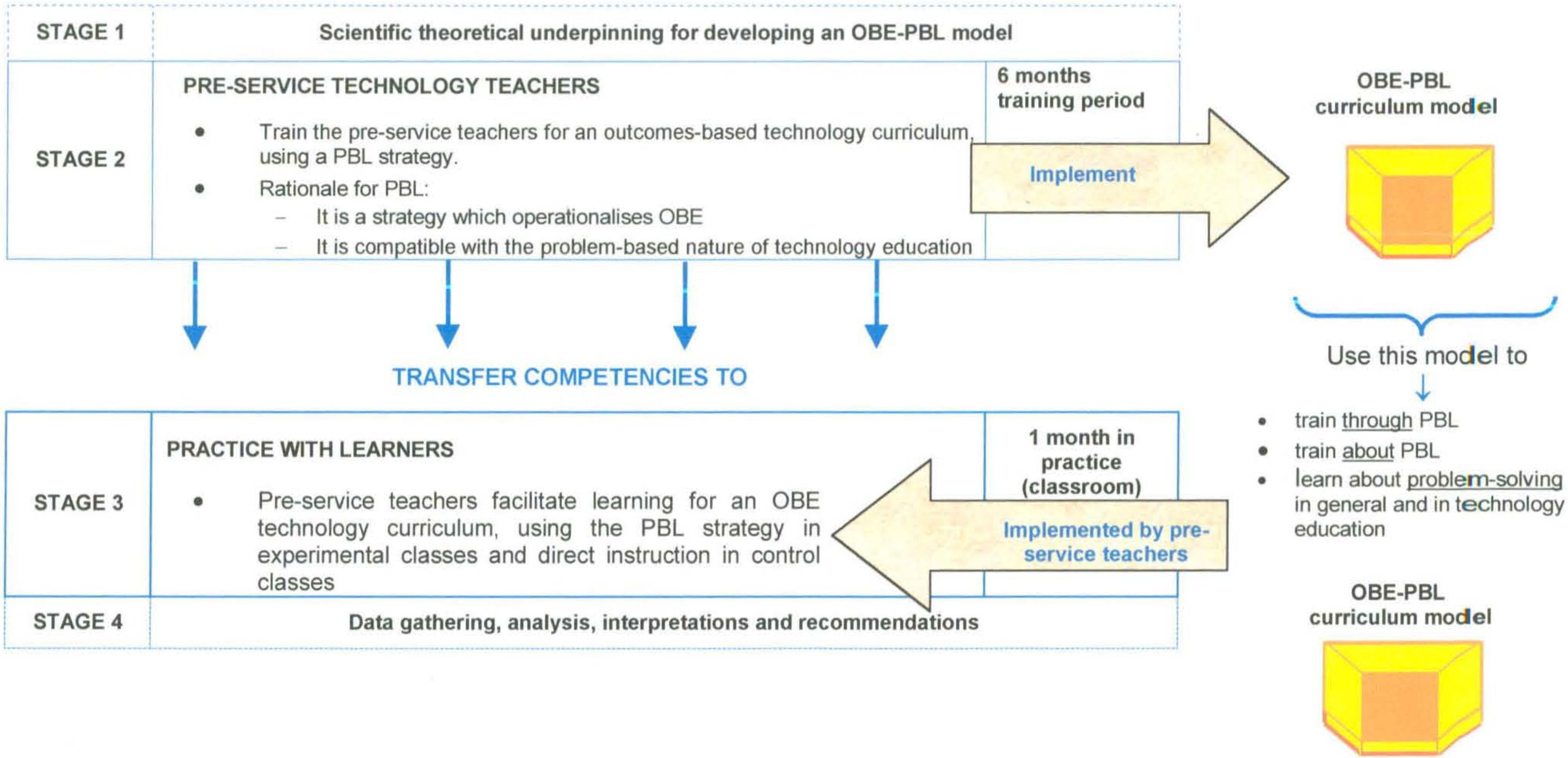
A researcher needs to give full account of the scientific methods, techniques and instruments which were employed to obtain valid knowledge in the search to answer the critical research questions (Landman, 1985:4, Bogdan & Bilken, 1992:58 and Schurink, 1998:241-242). This chapter will elaborate on the research design which is the "*plan or blueprint according to which data are to be collected to investigate the research hypothesis or question in the most economical manner*" (Huysamen, 1993:10).

The outcomes- and problem-based learning (OBE-PBL) curriculum model which was the outcome of Chapter 3 forms the meta-structure for the curriculum which was used in the training interventions of the pre-service teachers. After the training interventions the pre-service teachers had to transfer and demonstrate their competence in an authentic, real life context – that is the classroom with learners. The OBE-PBL curriculum model which served as the meta-structure for the pre-service teacher training, also served as the meta-structure for teaching in an authentic context. All the interventions with pre-service teachers and their interventions with learners of the experimental and control groups are reported in this chapter.

4.2 Research design

The research design broadly manifests itself in four stages giving an outline of the research activities to be undertaken. The following diagram provides a conceptual framework for the four stages to be discussed:

Figure 4.1: A conceptual framework for the research design



Stage 1

Chapters 2 and 3 have reported extensively on the theoretical dimensions of outcomes-based education, problem-based learning and technology education. The insights gained from the literature research led to the construction of a model called the OBE-PBL curriculum model, which would be implemented during later stages of the research.

Stage 2

The OBE-PBL curriculum model was implemented during stage 2 in the training of the pre-service teachers. The PBL training interventions ran for a period of six months. After the six month training intervention, it could not be assumed that pre-service teachers would facilitate an outcomes-based technology curriculum using a PBL strategy effectively – they had to transfer and demonstrate their competence in practice. This led to the third stage.

Stage 3

The OBE-PBL curriculum which served as the meta-structure for the training of the pre-service teachers, now served as a meta-structure for the pre-service teachers' classroom practice. The pre-service teachers had to transfer and apply their competence developed during training in a real-life context. The pre-service teachers went to different schools where they had different interventions with experimental and control group learners. Learning in the experimental groups was facilitated using the PBL strategy and all the principles associated with OBE and PBL. The control groups were taught using traditional lecture-based strategies, with separate practical sessions. More information about the experimental and control group interventions is provided in Section 4.5.2.

Stage 4

This stage entails the gathering, analysis and interpretation of research data and the making of recommendations. The main data sources are the pre-service teachers themselves and the experimental and control group learners with whom they have intervened. How the quantitative and qualitative data have been collected from these data sources will be discussed in the next sections on methodology and instrumentation.

4.3 Research methodology

This research is not based on a single methodology. According to Leedy (1993:139) the decision on which methodology to use, depends on *"the nature of the data and the problem for research"*. Creswell (1994: 177-178) describes a mixed methodology design where aspects of the quantitative and qualitative paradigms can be combined as was the case in this research. This approach adds complexity to a research design, but the main attraction of this design is that it uses the advantages of both the qualitative and quantitative paradigms.

The table below, also presented in Chapter 1 Section 1.5 gives a layout of the particular methodology used to gather the data.

Table 4.1: Data sources, instruments and methodology used

Resources: Data points	Data gathering instruments	Type of methodology applied
1 Grade 10 science learners	1 Pre- and post-knowledge test written by the experimental and control group.	The data from the pre- and post-knowledge test, the attitude questionnaire and the LEMOSS questionnaire were quantitatively analysed by means of empirical-statistical methods.
• Experimental group • Control group	2 An attitude questionnaire completed only by the experimental group.	The comments by learners from the experimental group were qualitatively interpreted to enrich the empirical findings obtained from the attitude questionnaire.
	3 The learning and motivation strategies in science questionnaire (LEMOSS) completed by experimental group learners.	
	4 Brief written comments by learners from the experimental group to determine reasons for their attitude	

2 Pre-service final year students	1 Written reports on their perceptions of technology and technology education prior to the PBL training. 2 Semi-structured individual interviews. 3 Log-books kept individually by each pre-service teacher of their practice implementation.	These instruments were qualitatively administered 1 The written reports were analysed. 2 The interviews were transcribed and analysed. 3 Written texts in the log-books were analysed.

4.4 Instrumentation

This section provides information to enhance the understanding of the different instruments which were used in this research and the rationale for using them.

4.4.1 The pre- and post-test written by experimental and control groups

All the grade 10 learners in all the different schools who were to be part of the research wrote the pre-test three months before the classroom interventions by the pre-service teachers commenced. This pre-test served several functions:

- It was used to pair off learners in the same school to create an experimental and a control group.
- The results of the pre- and post-tests for each of the experimental and control groups were compared to determine whether a meaningful difference between the pre- and post- tests existed. Since learners were paired off on their pre-test results, the post-test results of the experimental and control groups could be compared to determine whether significant differences exist between the experimental and control groups after their different interventions. The post-tests were written after the one month classroom interventions. Both tests were set by a practicing grade 10 science teacher, a grade 9 technology teacher in a pilot school and myself (the researcher). As a grade 8 through 12 science and math teacher and Head of a high school Science Department for nine years, I knew the level of knowledge and development of grade 10 science learners very well. Both tests assessed knowledge about

content and skills relating to technological and problem-solving processes. The tests included questions which were distributed across the six cognitive levels of Bloom's taxonomy. The pre- and post-test did not have exactly the same questions, but tested the same concepts on the same cognitive levels according to the Bloom taxonomy. See Section 5.2.1 for the complete pre- and post-tests where the marks for each question are indicated as well as the cognitive level.

The first six questions were adapted from the TIMSS (1996) and focused on general energy related principles and processes. Questions seven to nine focused on the major theme used in the PBL and traditional interventions, namely biogas as an alternative energy resource. The last question probed the technological process. The pre- and post-tests were written four months apart. This time interval between the pre- and post-tests provided enough time for reset by the learners. The pre- and post-tests analysis will be given in the next chapter when the experimental and control group results are presented.

4.4.2 *The attitude questionnaire*

This questionnaire was set by the researcher and consists of eight questions. It attempted to elicit learners' attitudes towards the PBL strategy and related issues such as the resource kit and co-operative work for example. Since it was only the experimental groups who were exposed to PBL, only they completed this questionnaire. It is included as Appendix 4. A questionnaire, rather than interviews were used to gather data about the learners' attitude towards PBL for various reasons. The large number (81) of learners in the experimental group, and the fact that approximately 20% of them were located 300 kilometers from the researcher's home, made it extremely difficult to conduct interviews. Interviews may have yielded richer data and this limitation is discussed in Chapter 6. On the other hand, if questionnaire data of the kind that were gathered were not available, the attitudes could not have been correlated with achievement, motivation and problem-solving strategies. This was done in Section 5.2.4.

4.4.3 *The Learning and Motivation Strategy Questionnaire in Science (LEMOSS)*

This questionnaire was developed by Basson, Goosen & Swanepoel (1996) to identify and interpret cognitive learning and motivation strategies in physical science (Basson, Goosen & Swanepoel, 1996:62). The type of questions asked to identify cognitive learning and motivation strategies are actually generic for any subject in the natural science Learning Area in secondary school education (senior and further education phase). Since grade 10 science learners were used who never had exposure to the new Learning Area of technology education, it was decided to use a questionnaire which referred to the term "science" in its questions.

The LEMOSS is an instrument which has been trailed with 984 secondary school learners (Basson, Goosen & Swanepoel, 1996:63). Three of the four schools involved in this research were also used in the standardisation of the LEMOSS instrument. However, no learners involved in the original LEMOSS research were involved in the present study. The LEMOSS consists of two domains namely cognitive learning and motivation with several fields under each of these. Each field is also made up by several questions. This information is presented in Table 4.2:

Table 4.2: Fields in the LEMOSS questionnaire

DOMAIN	FIELDS		NUMBER OF QUESTIONS
COGNITIVE LEARNING	1	Problem-solving strategies	10
	2	Critical thinking and conceptualisation strategies	14
	3	Planning and organisation strategies	7
	4.	Monitoring and understanding strategies	7
MOTIVATION	5.	Subject motivation	6
	6.	Intrinsic motivation	4
	7.	Extrinsic motivation	4

The LEMOSS questionnaire with its interpretation sheet is included in Appendix 8.

Guided by the research questions of this research, it was decided to use the data of only three fields, namely problem-solving, intrinsic and extrinsic motivation. These three fields were attended to in detail in the literature study in Chapter 3. Another reason for not using all the LEMOSS fields, is that the magnitude of manipulations would become too big and overwhelming for the type of comparisons and correlations which were envisaged for this research. For each of the experimental group learners, the LEMOSS fields mentioned would be correlated with *each* of the eight items in the attitude questionnaire. The questions which needed to be answered by correlation between the attitude and the three LEMOSS fields were the following:

- What are the attitudes of intrinsically motivated learners towards a PBL strategy?
- What are the attitudes of extrinsically motivated learners towards a PBL strategy?
- What are the attitudes of learners who have been identified to have low levels of problem-solving competence towards a PBL strategy?
- What are the attitudes of learners who have been identified to have high levels of problem-solving competence towards a PBL strategy?

These are subsets of research question 6 which was presented in Section 1.4 – these questions, collectively, answer question 6.

4.4.4 Written reports on the pre-service teachers' perceptions on technology and technology education prior to the PBL training

All the pre-service teachers who were involved in the PBL training programme for technology education, had to give their perceptions on technology and technology education in a written format. This provided a measure of the extent to which the PBL training contributed to their later perceptions on the same issues. Pre-service teachers had to answer the following questions:

- What is technology? Explain.
- What is technology education? Explain.
- Is there a difference between technology and natural science?
- What is the most effective methodology for teaching technology?
- What are the phases in the technological process?
- Do you think that South African education is ready to implement technology?

A coding scheme was developed by the researcher to analyse the perceptions of the pre-service teachers. The written reports were also independently analysed by a research colleague who is experienced in qualitative research. This analysis was used to validate the coding scheme and the analysis conducted by the researcher. It could also neutralise any biases which might be present unconsciously in the researcher. All the qualitative data generated in this research, was also analysed by the research colleague mentioned earlier.

4.4.5 The semi-structured interview schedule for pre-service teachers

Qualitative interviews may vary in the degree to which they are structured. A semi-structured interview schedule was compiled by the researcher who also conducted the interviews. Although the interview was guided by four focus questions, it was not intended to be rigid. It allowed respondents to talk about what was of central significance to them and allowed the interviewer to pick up on some issues initiated by the respondent and to probe more deeply. Interviews were conducted on an individual basis by the researcher with all the pre-service teachers who had been exposed to the PBL training and who have implemented PBL in real classrooms where they facilitated technology education. In one of the schools where two pre-service teachers were involved in team teaching, a combined interview was conducted. The interviews were conducted in the first week after the pre-service teachers had completed their practice experience. The following questions guided the interview and collectively provide information to answer research questions 4 and 5 in Section 1.4:

- This question probes the experiences of the pre-service teachers on their PBL training: **How did you experience the problem-based learning strategy in your training?**

- This question probes the pre-service teachers on their experiences with PBL in the authentic classroom situation with learners: **How did the learners experience the problem-based learning strategy? Think about your classroom experiences. Now tell me more about HOW you facilitated problem-based learning in the classroom.**

- This question probes the pre-service teachers' conceptualisation of technology education and to which extent the PBL training contributed to their conceptualisation: **How would you explain to a fellow student or parent what technology education is?**

- This question probes the pre-service teachers' impressions and understanding of OBE after both their PBL training and their PBL application in practice: **Technology education was facilitated within an OBE framework. What impressions of OBE have you gained through the PBL training and practice experience?**

The interviews were transcribed and analysed according to a coding scheme developed by the researcher. The details of the coding scheme are provided in the next chapter Section 5.3.2 where the qualitative results are presented.

4.4.6 The log-books kept by the pre-service teachers of their one month practice experience

The log-books served as a triangulation method for the data obtained through the interviews. Mouton & Marais (1990:72,91) recommend the use of multiple methods of data collection and claim that such triangulation increases the reliability of observations and conclusions drawn from data.

During and after the interventions with the experimental and control groups, the pre-service teachers had to critically reflect on their own experiences with the learners. They were knowledgeable about the fact that reflection entailed more than just writing down technical information on sequences of activities. Critical reflection was one of the topics which was addressed during their orientation period right in the beginning of the academic year, before they went to schools to do observation for three weeks. They had to capture in writing experiences, observations and reflections on the following issues:

- **Their own experiences of the learners and their responses to PBL.**

- **Their experiences with the PBL strategy in an authentic situation.**

- **Their PBL training. Did it prepare them for what they had to implement? What were the strengths and weaknesses of the training?**

- **Their understandings of OBE in general and in relation to technology education and PBL.**

- **Anything of value which could enhance the richness of data.**

The log-books were also analysed using the same coding scheme as for the interviews.

4.5 Background information on data sources

4.5.1 The pre-service teachers

The main source for obtaining data of a qualitative nature was the pre-service teachers. Although twenty pre-service teachers were trained for technology education using a problem-based approach, only the results of the six teachers who facilitated the one month intervention with experimental and control groups, were used for data analysis. The other 14 pre-service teachers had to do their one month school practice in their other subject when they went out to schools. Four of the six pre-service teachers had completed a Bachelors of Science Degree and were enrolled for the one year full time professional qualification namely the Higher Education Diploma (HED). This qualification prepares pre-service teachers to teach from grade 8 through 12. The other two students were in the fourth and final year of their Bachelors of Science in Education (BSc Ed) degree. They joined the classes of the HED students. The PBL training was done during a combined physical and general science subject didactics session for three hours once a week for 24 weeks (six months). The session started one hour earlier to accommodate issues which were directly linked to physical science and which could not be integrated with the technology Learning Area. The yellow block in Table 4.4 indicates this hour. Students have to enrol for two subject didactic sessions in their major subjects which they intend to teach. The demographic data of the six pre-service teachers is summarised in the following table:

Table 4.3: Demographic data of the six pre-service teachers

- **Sex:** Male:1 — Female: 5
- **Age:** 21 years: 4 — 22 years: 2
- **Academic qualifications:** BSc Degree: 4 — BSc Ed Degree: 2
- **Highest qualification in degree subjects:**
  Physics I: 3 — Physics III: 2
  Chemistry I: 5 — Chemistry III: 1
  Mathematics III: 2 — Physiology III: 2
  Bio-chemistry II: 1 — Industrial chemistry (Hons): 1
- **Currently enrolled in Higher Education Diploma (HED):** 4
  BSc Ed joining the HED classes: 2
- **Subject Didactics:**
  Physical Science: 3
  General Science: 3
  Biology: 3
  Mathematics: 3
- **Prior experience in technology education?**
  YES: 0 — NO: 6

All the pre-service teachers had science backgrounds but none of them had any experience in technology education the way it is conceptualised for this research and in Curriculum 2005. All six of these pre-service teachers volunteered to facilitate the experimental and control group interventions in practice.

All the subjects which the pre-service teachers had to take, as well as the three hour combined physical and general science subject didactics session are indicated in the table below. This table gives a full account of the academic curriculum to which the pre-service teachers were exposed.

Table 4.4: Faculty of Education: Time table for the Higher Education Diploma (Post Graduate)

	FULL TIME					
	TIME	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
1	07:30 – 08:20	Assessment session	Assessment session	*	*	Assessment session
2	08:30 – 09:30	*	Didactical Pedagogics	*	*	School guidance and counseling
3	09:30 – 10:30	Didactical Pedagogics	Teaching practice		Didactical Pedagogics	*
4	10:30 – 11:30	Teaching practice	School organisation and administration	Education Communication	Teaching practice	Human movement sciences
5	11:30 – 12:30	*	School organisation and administration	Educational Technology	Religious studies	School organisation and administration
6	12:30 – 13:30	*	*	Education Law Policy	*	Teaching practice
7	13:30 – 14:30	*	Physical and General Science Subject Didactics	*	*	*
8	14:30 – 15:30	*		*	*	*
9	15:30 – 16:30	Educational Technology		*	*	*
10	16:30 – 17:30	Education Law & Policy		*	*	*

* Subject Didactic sessions in other specialist subjects or Learning Areas.

The blue shaded area indicates the three hour contact session per week which was used for the research intervention with the pre-service teachers. Although the contact session was only three hours it did not mean that the pre-service students only needed to work on their problem-based tasks for three hours per week. On the contrary, most of the research for solving the problems took place outside the classroom in real places such as schools where they interviewed teachers and the library where they had to access information from various resources.

It should be noted here that apart from the subject Education Communication where pre-service teachers had to do practical communication tasks the dominant teaching strategy for all the other subjects, was lecture-based, accompanied by tests, exams and assignments as assessment strategies.

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4.5.2 The experimental and control groups

4.5.2.1 Selection of participating high schools

Initially eight principals of senior secondary schools (grade 8 through 12) in the Pretoria-Midrand area, where the pre-service teachers from the Pretoria University normally do their school practice, were approached to participate in this research. One principal in the Ellisras area was also approached, since one of the pre-service teachers obtained special permission to execute this research in that particular region.

After the research project was explained to the principals and the science teachers of the learners who were to participate, the Ellisras and four Pretoria-Midrand principals gave their permission to continue with the research in their schools. Principals also consulted with stakeholders such as the science teachers, parents and science learners themselves before they gave their consent. The principals generally appreciated the opportunity for their science teachers as well as their grade 10 science learners to be exposed to new OBE methodologies and practices. They also appreciated the fact that all resources and research kits used in the research would remain the property of the school after the research has terminated.

Principals who did not give their consent to work in their schools, were respected for their decisions. They gave the following reasons for not allowing the research to be conducted in their schools:They said that the academic curriculum for grade 10 science is very loaded with content, and that teachers would not finish the curriculum on which learners were to be examined at the end of the year. Some of them were concerned that they would get too much pressure from parents or governing bodies if the regular science curriculum was interrupted for a research project.They would have preferred experienced teachers to implement the OBE-PBL model rather than pre-service teachers.

4.5.2.2 Selection of experimental and control groups

One month prior to the interventions all the grade 10 learners in all four schools wrote a pre-test. These pre-test results would later be used to pair off learners for experimental and control groups which could be statistically compared. When the pre-service teachers arrived at the schools two of the principals allocated two grade ten science classes to the pre-service teacher to work with. In two of the schools the pre-service teachers could decide on any two grade 10 science classes to work with. It was up to the pre-service teachers to randomly decide which classes should be treated as an experimental and which as a control group. The number of learners involved in experimental and control classes in each school **before any pairing off** is indicated in Table 4. Note that the term class is used before learners are paired off, but once learners have been paired off statistically, the term group will be used.

Table 4.5: Number of learners in the experimental and control classes in each school

SCHOOL	EXPERIMENTAL CLASS	CONTROL CLASS
A	20	21
B	20	23
C	22	24
D	19	21
E	21	25
Total	102	114

Unfortunately all the data obtained from school E had to be ignored, as well as the data obtained from the particular pre-service teacher. The experimental and control groups treated by this pre-service teacher did not write the post-test after the intervention. The pre-service teacher gave the reason for not letting the learners write the post-test as a shortage of time to do so. Table 4.6 gives an indication of the schools and number of learners who were finally used in the interventions:

Table 4.6: Number of learners in the experimental and control classes in each school without school E

SCHOOL	EXPERIMENTAL CLASS	CONTROL CLASS
A	20	21
B	20	23
C	22	24
D	19	21
Total	81	89

After an experimental and control class have been identified in the different schools, it could not be assumed that the two groups in a particular school started off on equal levels and were thus statistically comparable. This assumption had to be tested first. The data set had a normal tendency, but was not perfectly normal. Therefore, a Mann-Whittey test, also called Wilcoxon Rank Sign Test, was used to determine whether there was a significant difference between the pre-test averages in the two classes. The Mann-Whittey test ignores the fact of whether a data set is parametrically distributed or not and gives an indication of the significance of the differences between the experimental and control classes. A t-test is used where it may be assumed that the data set is parametrically distributed or normal (Steyn, Smit, Du Toit & Strasheim, 1996:365-366). The p-values generated from this test did however indicate that in all four of the schools the pre-selected experimental and control classes were **significantly different** on the pre-test. Table 4.7 shows the results for the total number of learners in the experimental and control groups respectively:

Table 4.7: Pre-test results before pairing off

	EXPERIMENTAL	CONTROL
N	81	114
Mean value (X) Percentage (%)	59,12	62,82
Std. Dev. (s)	17,9747	15,3291
Mann-Whittey: p-value	**0,0450***	

* $p < 0.05$

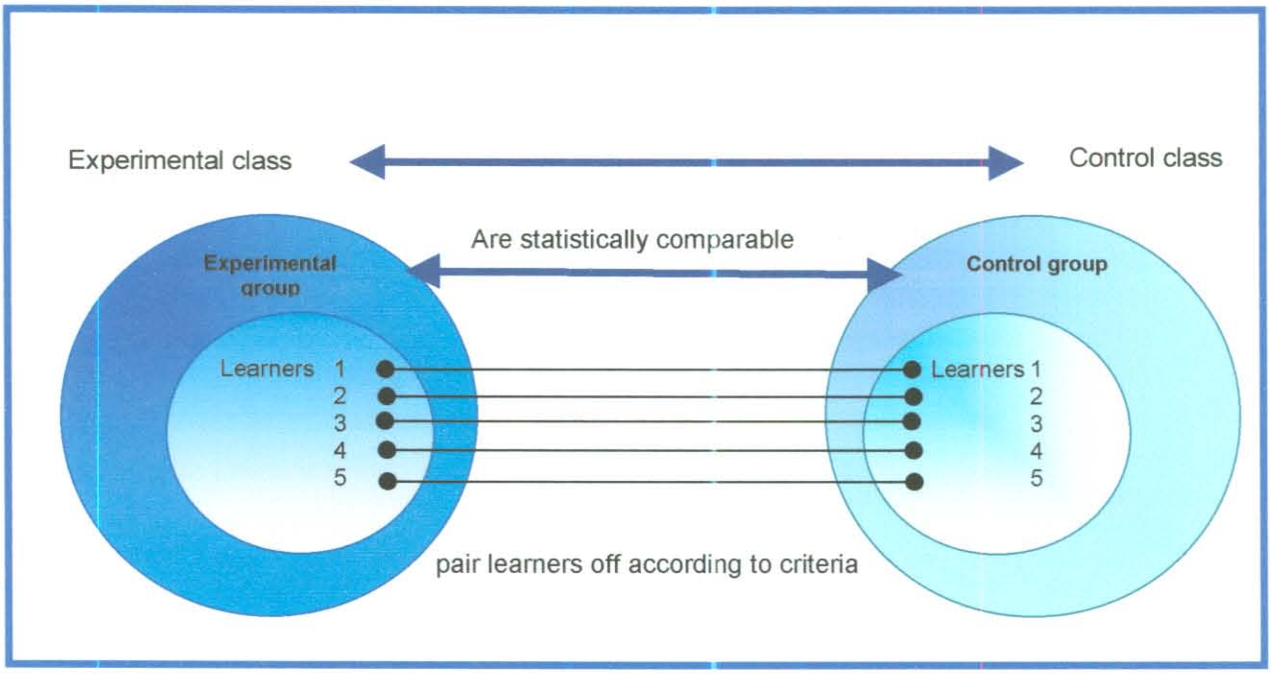
This outcome called for a strategy which could be used to identify within each of the classes which learners could be paired off to form two groups which would be statistically comparable. In other words, two groups within the experimental and control classes in each school had to be identified which would start off on statistically equivalent performance levels in terms of their knowledge before interventions proceeded. The following set of criteria was used to pair off learners for the creation of a statistically comparable experimental and control group. The criteria were:

- Learners in the same school were paired off.
- Learners of the same gender were paired off.
- Learners in the same school and gender who had exactly the same pre-test marks were paired off.

The number of learners adhering to these criteria were 19 experimental and 19 control learners in total in all the schools. Since this sample was too small (< 30), it was decided to also pair off males and females separately who differed 1% from one another on their pre-test mark. The number of experimental and control learners who adhered to these criteria was now 31 in each group in total. Finally it was also decided to pair off males and females separately who differed 2% from one another in the pre-test scores. The number of experimental and control learners who adhered to these criteria was 70 in each group in total. The Mann-Whittey test was finally run again for this newly created experimental and control group to check whether these two groups started off on the same level and were thus statistically comparable. Any significant differences which might be present in the post-test later, could then be ascribed to interventions by the pre-service teachers.

The following diagram summarises the processes described above:

Figure 4.2: Process of creating statistically equivalent experimental and control groups in each school



All four the experimental groups in the four schools form the collective experimental group for the research. The same principle applies for the control group of the research.

Table 4.8 gives a statistical picture of the pre-test results of the newly created experimental and control groups:

Table 4.8: Pre-test results after pairing off

	EXPERIMENTAL GROUP	CONTROL GROUP
N	70	70
Mean value (X)	61,7857	61,8286
Std. Dev. (s)	15,7847	15,6899
Mann-Whittey: p-value	0,7990	

The p-value resulting from the Mann-Whittey test is greater than 0,05. This indicates that there is no significant difference between the pre-test performances of the newly generated experimental and control groups. The experimental and control groups to be compared after the post-test, start off on equal levels of performance. In both groups there were now 43 females and 27 males. The average age in both groups was 16 years. The experimental group had 18 learners of age 15, while the control group had 23. The experimental group had 4 learners of age 17, while the control group had 3.

The ideal experimental situation now would have been to separate the statistically comparable experimental and control group learners from the other learners in the classes who did not adhere to the pre-selected set of criteria. This, however could not be done due to various ethical and practical organisational factors. In this research learners who did not adhere to the criteria of a statistically pre-selected experimental or control group could not be "harmed" by being sent out of the classroom in official school hours, while the experimental and control groups were exposed to the research interventions. Practically these learners could not be accommodated somewhere else and looked after by other school personnel for the one month duration of this research. The researcher is of the opinion that doing research in real authentic classrooms, which are far from ideal laboratory circumstances, enhances the validity and authenticity of data.

4.6 Research interventions

This stage of the research provides an overview of the research interventions with the pre-service teachers as well as the experimental and control groups.

4.6.1 Research interventions with the pre-service teachers

For the **first three months** physical and general science subject-didactic course, the problem themes focused on the various dimensions in the OBE-PBL model. During the **last three months** the overarching problem to be solved entailed the execution of the 'real thing' which entails designing, developing and facilitating OBE-PBL technology tasks. During the last three months pre-service teachers acted as learners for one another when it was not their turn to facilitate a problem-based technology learning task. The solving of these problem-based tasks involved the integrated application of all knowledge and competencies practised in the first three months.

The pre-service teachers, acting as learners, were simultaneously exposed to technological knowledge and competence in the technology-science education curriculum as well as to the experience of utilising the PBL strategy. The rationale behind this strategy was to let the pre-service teachers experience both sides of the "coin" as a learner. On the one side they had to work through problem-based learning tasks covering sections of the technology education curriculum, and on the other they experienced using the PBL strategy from a learner's perspective. When they did not act as learners for one another, they practised their professional competence associated with PBL, as well as the seven educator roles discussed earlier in Chapter 3.

The anticipated experience of PBL evoked many questions in the minds of the pre-service teachers about how they would be assessed in this particular course. Enough time was given to tease out the questions and uncertainty on the side of the pre-service teachers about the assessment strategies and criteria. This was important given the pre-service teachers' lack of experience with this new strategy and the assessment strategies related to it. No tests or exams were scheduled, but other assessment strategies and tools were used to assess them formatively and summatively. The assessment varied from PBL task to task and will briefly be mentioned when a summary of monthly training interventions are described below.

Interventions during months one to three

Although only six pre-service teachers finally facilitated the PBL in the real classrooms, twenty were enrolled altogether for this particular course. For the first three months pre-service teachers had to work in co-operative groups. They were divided into three groups of three members each and one group with four members. For each new problem introduced the group membership altered. This allowed for maximum interaction, group dynamics and multiple relationships and resources between peers. It was also an attempt to prevent the forming of cliques in the class, which can become a problem if groups remain unchanged for too long. Refer to Section 3.3.6 where this research finding was discussed.

After the groups have engaged in the problem-solving process they had to present their solutions either to peers in the same class, peers enrolled for any education orientated course or subject, parents who wanted more information about the new directions in their children's school education and/or teachers at a local school. The presentation had to last about 35 minutes with 15 minutes questioning time. The pre-service students negotiated an arrangement with lecturers in some of their other subjects to present their solutions in those classes. The rationale for doing this according to the pre-service teachers is that the nature of problems of the first three months were very relevant for the subject Didactical Pedagogics. (The name of this subject is currently being changed to Curriculum and Instructional Design and Development). After the presentation of the problem solutions, a critical reflection and general debriefing on the presentation and the quality of problem solution were done by the researcher. Since the researcher was also the lecturer of this course, the terms "researcher" and "lecturer", are sometimes used interchangeably in the rest of this chapter.

Assessment for the problems solved in the first three months were conducted in a manner presented in table format below. The table shows what is assessed, gives a mark breakdown, indicates who is assessed and by whom the assessment is done. The following tables summarising the multitude of components associated with the various interventions will not be numbered individually.

WHAT IS ASSESSED?	MARK BREAK DOWN (100%)	WHO IS ASSESSED?	ASSESSED BY WHOM?
Written research portfolio (documentation of problem-solving process)	40	Individual	Lecturer
Public presentation of the solution	50	Co-operative group	Other three co-operative groups Lecturer
Contribution by each co-operative group member	10	Individual	Peers in the same co-operative group

All the details of all the problems, their presentation format and the appropriate resources will not be given here. One typical example of a problem and its presentation will be given after the interventions during the first month are discussed. The reason is that numerous problems were used around which the exit level outcomes of this course were organised. Each pre-service teacher and co-operative group also did not receive exactly the same problems to solve. Once a particular individual or co-operative group had solved the problem, they always had to report back to their fellow pre-service teachers who did not have the same problem and who would peer assess their colleagues' problem-solving process and solution.

The training interventions with the pre-service teachers in month one to three are summarised in terms of a broad focus in which various problems were formulated for various co-operative groups, as well as the minimum resources which were used to present a problem as creatively and authentic as possible. The following tables will present this information.

MONTH 1	
Problem focus for the different co-operative groups:	**Co-operative group 1 and 2:** Educational transformation and the role of OBE in educational transformation in South Africa.
	Co-operative group 1 and 2: OBE as a philosophy and the OBE systems (SAQA, NQF) in place to operationalise this philosophy.
	Co-operative group 3 and 4: OBE in practice: planning, designing and implementing OBE.
	Co-operative group 3 and 4: The seven educators roles, associated, knowledge and competencies. The new role of a teacher as facilitator of learning.
Authentic resources	• Current, sensational newspaper and magazine opinions

used for problem presentation and solution	and debates on OBE. • Television broadcasts on education reform in South Africa. • Latest policy documents, curriculum frameworks and the speech of The SA Minister of Education launching Curriculum 2005. • Curriculum 2005 • Relevant literature

An example of a typical detailed problem that was presented to pre-service teachers in co-operative groups 3 and 4 will be presented here:

Problem presentation

When the pre-service teachers entered the classroom, they were shown three video clips which were on the SA television news broadcast about the educational reform in South Africa, and the launch of the new Curriculum 2005. This was very relevant since Curriculum 2005 was launched in the year that they started their Professional Diploma in Secondary Education.

They were also presented with a resource kit containing various popular articles from newspapers and magazines, as well as the speech from the SA Minister of Education, Prof Bengu announcing Curriculum 2005. Each co-operative group received a copy of the resource kit. Each article in the resource kit reflects a particular point of view, or opinion about OBE, Curriculum 2005 and its implications for South African education. After they familiarised themselves with the issues and questions raised in the popular literature, they were allowed to have informal discussions, arguments and debates with their co-operative members and also with other peers in other co-operative groups. The articles provoked lively discussions. Once they had fully experienced the material and the socio-constructivist classroom dynamics, they were confronted with the following process. This is a fictional scenario prepared by the lecturer for each pre-service teacher to make the experience personal and real.

Each pre-service teacher received a letter personally addressed to them from the principal of the school where they will start their teaching careers the following year. One letter will be given here as an example. For the pre-service teachers in co-operative group 3 and 4 the "principal" wrote the following addressed to each individual (All names and addressed are fictional for the purpose of the research report in order to conceal identities):

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

XYZ Secondary School

Know & Do

20/06/1997

Dear Ms Pre-Service Teacher

It is a privilege for me to welcome you as a new colleague who will be joining our school next year. I want to invite you to our annual meeting at the beginning of the academic year, where new staff will get the opportunity to meet with existing colleagues.

I also want to use this opportunity for you to share with us your expertise as a new graduate who is up to date with the latest developments in the field of secondary education. I am sure that you can be valuable to our teachers. – some of whom have graduated 15 – 20 years ago. I will really appreciate it if you can brief the teachers from your perspective as a graduate fresh from university on the following question/topic:

How will OBE influence or change our every classroom practice?

You might want to refer to the impact of OBE on our

- Daily planning and preparation for teaching
- actual teaching and the teaching strategies which we should use
- assessment methods and tools.

You have more or less 45 minutes on the programme. If you need more time, I will arrange it for you. I sincerely hope that you will be willing to do this. Please confirm with me personally as soon as possible.

Kind regards.

....

Ms Principal

The interventions during month 2 will be discussed now.

<table>
<tr><th colspan="2">MONTH 2</th></tr>
<tr><td>Problem focus for the different co-operative groups:</td><td>Co-operative group 1 and 2: PBL as curriculum and teaching strategy in OBE.</td></tr>
<tr><td></td><td>Co-operative group 3 and 4: Problem-solving strategies for PBL</td></tr>
<tr><td></td><td>All the co-operative groups: Analysing the PBL curriculum of the Medical School at Pretoria University.</td></tr>
<tr><td></td><td>All the co-operative groups: Designing and compiling PBL resources, materials and research kits.

In this particular research the pre-service students were provided with a framework for compiling and designing a resource kit for the problems which they had to design in technology education.

• Contextual resources: These resources aim to contextualise the problem in that they provide a vehicle to examine the ethical, social, environmental and other issues related to the specific problem. In technology education, these resources are providing the enriched background for comprehending the particular need which becomes the problem to be solved in a technological way. The need-driven nature and structure of technology education is addressed in detail in Section 3.5.2 of this chapter.

This category of resources might include recent news flashes about the need or the problem in newspapers, magazines or other telematic delivery systems such as a video for example. It might also include short activities or tasks which learners have to execute to perceive the depth and breath of the problem that needs to be solved.

• Research resources: These resources aim to provide materials needed to develop learners' knowledge and skills which will be needed to solve the problem innovatively and successfully. It might also include activities and tasks, especially in a Learning Area such as technology, where learners have to master certain skills first before they can attempt more complex skills which they will need in the technological process.

Apart from the written materials, other research materials, which might not necessarily be a physical part of the resource kit might also be made available to learners, such as videos, films, slides and internet addresses. Field trips</td></tr>
</table>

	also proved to be a rich and valuable resource. • **A meta-learning checklist** For learners who are exposed to a PBL design for the first time which demands self-directed learning, a meta-learning checklist can be a value adding tool. In this research a meta-learning checklist was included for each learner in the resource kit. This checklist may be perceived as a self-pacing facilitation instrument which asks reflective questions in the immediate absence of a facilitator. The ultimate aim is not to keep learners dependant on this checklist. Once learners have internalised the meta-learning skills, any external locus of control such as a checklist or a teacher who guides the learning process, should become redundant. Since the learners involved in this research were not often exposed to self-directed learning, the checklist forces learners to reflect on the different elements of meta-learning namely, planning, monitoring of the execution process and evaluation while solving a problem. The meta-learning checklist is included as Appendix 5.
Authentic resources used for problem presentation and solution	• A site visit to the medical campus of Pretoria University where a PBL curriculum is partly implemented. • Interviews with third and fifth year medical students who are experiencing a problem-based curriculum. • Relevant literature.

MONTH 3	
Problem focus for the different co-operative groups:	**All the co-operative groups:** Science and technology education in South Africa and internationally.
	All the co-operative groups: The nature and structure of technology education and its relationship with science and other Learning Areas.
	All the co-operative groups: The technological process.
	All the co-operative groups: Knowledge and competencies for facilitating learning in technology education.
Authentic resources used for problem presentation and solution	• The White Paper on Science and Technology in South Africa. • Video extracts of teachers teaching technology education

	in various pilot schools in South Africa. • A site visit to a high school where technology education is implemented in a pilot project. • Discussions with the technology teachers and learners about the teaching strategies they use. • Relevant literature

Interventions during months four to five

During these months, the pre-service teachers had the opportunity to integrate and practice the knowledge and competencies, which they were exposed to in the first three months of their PBL training. Each individual actually had to design, develop and facilitate learning in problem-based technology learning tasks.

The assessment for month four and five was exactly the same. The technological competence of pre-service teachers **acting as learners** were assessed in the following way:

WHAT ASSESSED?	MARK BREAKDOWN (100%)	WHO IS ASSESSED?	ASSESSED BY WHOM?
Written design portfolio (documentation of the technological process)	50	Individual acting as learner	Lecturer Pre-service teacher responsible for the PBL learning task
Problem or technological solution and prototype where applicable	50	Individual acting as learner	Lecturer Pre-service teacher responsible for the PBL learning task

A **pre-service teacher** who was responsible for the design, development and implementation of a technology problem-based learning task was assessed in the following way:

WHAT IS ASSESSED?	MARK BREAKDOWN (100 %)	WHO IS ASSESSED?	ASSESSED BY WHOM?
• Written PBL task design and development • Facilitation of the PBL task • Resource kit	PBL task design: 30 Resource kit : 20 Facilitate PBL task: 50	Pre-service teacher responsible for the PBL learning task	• Peers who executed the PBL technology learning task • Lecturer

The interventions with the pre-service teachers during month four and five are summarised in the table below:

MONTHS 4 AND 5	
Problem focus for the individual pre-service teacher	Individual pre-service teachers engaged in the "real thing" of designing, developing and facilitating learning in OBE-PBL technology tasks.

Interventions during month six

Training during this month involved the final pre-practice interventions with the pre-service teachers before they would go out to the schools. During this month the pre-service teachers were subjected to a typical problem based technology learning task designed by the researcher - complete with a resource kit. This was the same problem-based technology learning task they were to facilitate in the science classes the following month. After the pre-service teachers have experienced what the science learners would be experiencing soon, they had the opportunity to critically reflect on and scrutinise the PBL task design. As a class they had the opportunity to adjust, redesign and change the problem and resource kit the way they wanted to, since they had to take ownership and responsibility for it in practice. The final version of the problem is presented in the next Section 4.5.2 where the interventions with the experimental groups are discussed. The only demand from the researcher was that they had to go "out there" with a uniform design and resource kit. The six pre-service teachers who were taking on the challenge of facilitating PBL in real classrooms, were not selected statistically according to standardised criteria. They were volunteers. Furthermore, no empirical data would be collected from them on which statistical tests had to be conducted, only qualitative data analysis. The pre-service teachers were equivalent in that they were all fourth year pre-service science-technology teachers; they all received exactly the same training through the OBE-PBL model for six months; they all volunteered to take up the challenge of facilitating learning in real schools according to the OBE-PBL model; they all used exactly the same problem-based learning task design, instructional plans for the experimental and control groups and resources which were developed collaboratively. The researcher was also in very regular contact with them at the schools where they were teaching. They could contact the researcher at any time if they wanted questions answered.

The interventions in the various schools therefore would have been similar, but not necessarily identical. In the human sciences, where people cannot be calibrated and standardised to perfection, like in the measurable world of hardcore sciences, differences may be present which might influence student learning. These differences will result from differences in the teachers in relation to attributes such as level of confidence, enthusiasm and communication skills, which is a reflection of real life teaching and realities.

Finally, when the pre-service teachers presented their technological solutions to the problem-based technology learning task, two external observers were invited to assess the quality of the technological solutions generated through the vehicle of the problem-based learning strategy. The one observer is a professor in science education at the University of Pretoria. The other observer holds a Masters Degree in Physics and is a consultant to the Department of Minerals and Energy in South Africa. The rationale behind this person as an energy specialist observing, is the fact that the main theme around which the problem-based technology task was designed, was energy, alternative energy resources and appropriate technological devices and systems to generate, store, transmit and/or use the energy.

MONTH 6	
Problem focus for the different co-operative groups:	**All the co-operative groups:** Executing a typical OBE-PBL technology learning task that was designed, developed and facilitated by the researcher. The theme of the problem-based learning task was energy and alternative energy resources. See Section 4.6.2 for the full problem description.
Resources for solving the tech-nological problem	The research kit compiled by the researcher and any other and relevant resources.

Together with the researcher, the external observer also had to assess the quality of attainment of the intended specific technology and natural science outcomes. All the intended outcomes are presented in Section 4.6.2. during the final month of training, the pre-service teachers were assessed as follows:

WHAT IS ASSESSED?	MARK BREAK DOWN (100%)	WHO IS ASSESSED?	ASSESSED BY WHOM?
Written design portfolio (documentation of the technological process)	25	Individual pre-service teacher	• Lecturer
Problem or technological solution and prototype where applicable	25	Co-operative group	• Lecturer Co-operative groups assess the technological solutions and devices of other co-operative groups
Demonstration of technology specific outcomes	25	Individual pre-service teacher	• Lecturer • External observer
Demonstration of natural science specific outcomes	25	Individual pre-service teacher	• Lecturer • External observer

During this month, the interventions with the control groups were also discussed, standardised and finalised. The same pre-service teacher who was going to facilitate the problem-based learning task with the experimental group also had to work with the control group in that particular school. Full account of the interventions with the control groups is given in Section 4.6.2. Table 4.9.

Interventions during month seven

During month seven the pre-service teachers facilitated the uniform problem-based technology learning task with grade 10 science learners in the experimental groups. They also taught the control groups using mainly direct instruction with lectures and practical demonstrations. The researcher and the external observer visited each of the schools at least three times per week to monitor the progress, make observations, write field notes and support the pre-service teachers in various ways necessary.

The six pre-service teachers were not assessed by the researcher for their classroom interventions with the experimental and control groups. They were stressed and nervous enough as it was to face the challenge of working with real learners. Assessment of the pre-service teachers' performance in the experimental and control groups was not the purpose with the authentic classrooms practice. Studying their competence in facilitating the problem-based technology learning task, the learner responses and meaningful learning from the perspective of the research questions, was the purpose.

4.6.2 Research interventions with the experimental and control groups in the authentic context

One month before the pre-service teachers went to the schools, the learners in all the participating schools wrote a pre-test. It was used to create statistically equivalent experimental and control groups in the various schools, as was described in previously in Section 4.5.2.2.

After the six month training period, the pre-service teachers went to different schools to implement the OBE-PBL model with the experimental groups. The control groups were subjected to traditional teacher and content centred teaching strategies and learning environments. It was paramount that the interventions (learning tasks, plans and resources) with the experimental and control groups had to be standardised. The same pre-service teacher who was responsible for facilitating the PBL task also had to teach the control group in a particular school.

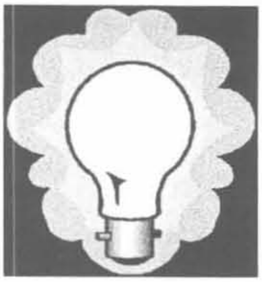
The specific outcomes from the technology and science Learning Areas, which had to be demonstrated by the learners after the interventions, are presented below. The associated assessment criteria and range statements for the specific outcomes from the natural science Learning Area will be included as Appendix 9. The same information for the technology Learning Area is available in Appendix 3.

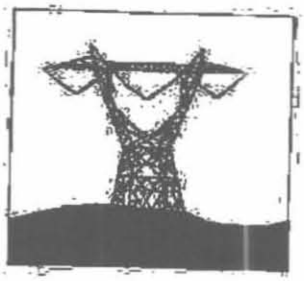
ENVISAGED TECHNOLOGY AND SCIENCE OUTCOMES
LEARNING AREA: TECHNOLOGY
• **Specific Outcome 1** Understand and apply the technological process to solve problems and to satisfy needs and wants. • **Specific Outcome 2** Apply a range of technological knowledge and skills ethically and responsibly. • **Specific Outcome 4** Select and evaluate products and systems.

LEARNING AREA: NATURAL SCIENCES
• **Specific Outcome 2** Demonstrate an understanding of concepts and principles and acquired knowledge in the natural sciences. • **Specific Outcome 3** Apply scientific knowledge and skills to problems in innovative ways. • **Specific Outcome 5** Use scientific knowledge and skills to support responsible decision making.
This particular problem-based learning task resides under the natural science theme: Energy and Change
The natural science Learning Area has been organised around four themes. These are the following: • The planet earth and beyond • Life and living • Energy and change • Matter and materials The scope statement for the ENERGY theme is: The concept of energy is fundamental to understanding both processes of change and life processes. Learners must understand, at an appropriate level, how energy is transferred in biological and physical systems; the resultant changes – including movement as change – in those systems; and that successive energy transfers make less energy available for useful work. Learners must appreciate human needs and aspirations that affect the choice of energy sources and the implications of those choices for the environment. Within this theme, learning contexts should be drawn from ***sources of energy; uses of energy; transfer of energy;*** **and** ***forces and movement as change.*** (Department of Education, 1997a: 86-94, 136-138)

The experimental groups were subjected to the same intervention as the pre-service teachers during month six (See Section 4.6.1). During the critical reflection where pre-service teachers had the opportunity to scrutinise the design, they suggested a *more realistic problem presentation*. In their intervention, a letter from Department Minerals and Energy explaining a need/problem was handed to them by the researcher. The pre-service teachers, however, suggested that when learners arrive at the class, a person playing the role of an employee from the Department of Minerals and Energy should hand an official letter containing the need/problem to each learner individually. Learners should then be left to read through the problem to experience the full impact of its content. The employee could then reinforce the need and problem stated in the letter and answer questions which learners might have. The employee becomes an authentic resource in the phase of clarifying and understanding the problem to be solved and the need to be addressed. This suggestion enhanced the authenticity and quality of the problem-presentation. The external observer fulfilled this function. The letter explaining the need and problem is presented below:

DEPARTMENT OF MINERALS AND ENERGY





Research and Development Division

The Managing Director
Energy Consultancy Company
Pretoria
0001

Dear Sir or Madam

ENERGY RESEARCH: ALTERNATIVE RESOURCES AND ASSOCIATED TECHNOLOGIAL HOUSEHOLD DEVICES

A problem in South Africa, which is also of global concern, has to be addressed, researched and solutions come up with as soon as possible.

The problem is the following:
As you might be aware, South Africa as the rest of the world, has only enough traditional energy resources left for approximately the next 20 years. Our company cannot postpone *intensive, focused research* in this future crisis area any longer. 196 companies in South Africa and 992 companies world wide are competing in the race for alternative energy resources and associated energy devices.

The alternative energy resource researched by our company will have to adhere to the following demands:

- It must minimally provide for the domestic energy needs for a household of 4 people.
- It must be one of the cheapest resources of energy. All types of households, whether low or high income, should be able to utilise this energy resource and its associated technological device.

- The National Electricity grid provided by ESKOM cannot be expanded to every remote town and rural village everywhere in South Africa. It implies that the alternative energy resource should be available in the remote rural areas.
- The alternative energy resource and its technological household device(s) must be environmentally friendly and safe and conserve the natural surroundings.
- Knowledge about a suitable alternative energy resource must be put to use in a particular household device(s).

Design the technological household device(s) which will be able to store, transform and/or distribute the energy for human needs. You also need to build a working prototype of your design.

A detailed research and design portfolio will have to be compiled and presented to delegates from the Department of Minerals and Energy and other interested role players who might want to contribute towards further development financing.

Each team member will be responsible for a section of the presentation. All prototypes have to be demonstrated to role players. Prepare yourselves for a press conference directly after the presentation and demonstration to the Department's delegates.

You have approximately 20 man-hours to complete this project.

We, as the board of directors trust that we can rely on high quality, professional work which will contribute towards the creation of a energy sustainable future for all the global citizens.

Good luck!

....

A Van Loggerenberg

Central Executive Officer (CEO)

The control groups were treated in traditional ways using teacher and content centred strategies for teaching and learning. The traditional curriculum, which is the oldest and best known form of curriculum, was discussed in detail in Chapter 2 section 2.2. Killen (1996:9) also contends that teachers are most familiar with content-based learning programmes where the emphasis is almost exclusively on "*covering the curriculum suggesting that teachers should teach a predetermined amount of content in each time period such as a lesson, term or year*".

In the control classes the topic and sub-topics to be covered in the weeks to follow were announced by the pre-service teacher. Once the topics were announced, twelve thirty minute lessons were presented by means of direct instruction to the whole class. Rosenshine (1987:34) explains that the emphasis in direct instruction is on *"teaching in small steps, providing for student practice after each step, guiding students during initial practice, and providing students with a high level of successful practice".*

Learners received notes on the content and the technological process, which were summaries compiled by the pre-service teachers. The notes fulfilled the function of the textbook since none of the prescribed textbooks covered the particular topic in full detail. These summaries were compiled for the learners from the resource kit, which the experimental learners had to use during the research in problem-solving process. The control group received all the information they needed in pre-packed format. They merely had to receive the information and memorise it through repetition and rehearsal. These actions presuppose that the human mind is regarded as an empty bucket which needs to be filled with knowledge which can be stored in the memory (Wilkerson & Gijselaers, 1996:14).

At the end of the lesson, each learner individually had to complete a typical end-of-the-period exercise for home work, which was marked in the class the next day. The lectures were followed up by two one-hour experiment sessions. While executing the experiments learners mainly worked in groups of four. However, these groups did not function as co-operative groups. The assignment design and the group composition did not adhere to criteria for co-operative learning. The criteria for co-operative work to be classified as co-operative work are described in Section 3.4.3. Learners were merely put together for the duration of the practical work session.

For the final energy device, learners received a design plan from which they had to build the device. Learners had to build the device individually. The final prototype of the device was the same for all the learners, since there was no problem to be solved. The researcher, together with the pre-service teacher assess the quality of the device. Actually, only the ability to work from a prescribed plan and the quality of the craftsmanship could be assessed. The process of arriving at a solution and designing a device to solve the problem could not be assessed as was the case with the experimental group. After the one month classroom interventions the experimental and control groups wrote the same post-tests in the same time slot on the same day. Table 4.8 below summarises the main differences between the interventions with the experimental and control groups:

Table 4.9: Comparative summary between the experimental and control group interventions

EXPERIMENTAL GROUP INTERVENTION	CONTROL GROUP INTERVENTION
Approach: Learner centred approach to teaching and learning. High levels of learner responsibility and activity.	***Approach:*** Content and teacher centred approach to teaching and learning. Low levels of learner responsibility and activity.
Teaching strategy: Problem-based learning	***Teaching strategy:*** Direct instruction: • Lessons presented (lectures). • Two practical work sessions. • Working sessions for building the technological device.
Creation of a learning conducive environment: Problem was presented to create an authentic learning context.	***Creation of a learning conducive environment:*** No problem was presented. The topic and sub-topics to be studied were announced prior to each lesson.
Learning materials: A resource kit and any relevant materials which learners wanted to use in their research. No typical end of the chapter exercises to be completed.	***Learning materials:*** Notes which were summarised by pre-service teachers containing all the information needed to do the exercises. Learners could also use any relevant resources if they wanted to. Typical end of the chapter exercises and questions after each learning session.
Teacher role: Facilitator of learning. Gives feedback and emotional support to co-operative groups	***Teacher role:*** Teacher teaches by presenting lessons. Teacher plays the dominant role and is

and individual learners where necessary. Learners are predominantly in control of their own learning.	responsible for the learning of learners.
Learner roles: Learners are actively discovering, researching and constructing meaning. They are practicing the competencies involved with solving a problem.	***Learner roles:*** Learners are passive recipients of knowledge. They listen to the teacher who asks questions, ask questions and complete the exercises using the notes (text book).
Learners work co-operatively with built in and individual accountability in the problem design. They practice brainstorming, group dynamics, meta-cognitive reasoning when in discourse with one another and social skills.	Learners work mainly individually. Individual mastery, success and accountability are promoted. During the practical sessions they did work in groups for the duration of the session.
Feedback: Learners get continuous feedback from co-operative group members and the learning facilitator.	***Feedback:*** Learners get feedback from the teacher when the end of the chapter exercises are marked and if learners ask questions during the lectures.
Presentation of the problem-solution to the representative of Department Minerals and Energy, other class members and teachers in the school.	A device was built from a pre-determined plan all the solutions were not generated by the learners, since there was no problem to be solved – just content to be covered. Learners did show their final devices to other members in the class. All the devices were similar anyhow.

4.7 Summary

This chapter has focused on the research design, methodology and interventions with all the various participants in this research. The intervention with the pre-service teachers and their interventions with the experimental and control groups in the different schools were reported on elaborately. The chapter concluded with a comparative summary of the difference between the teaching and learning strategies used in the experimental and control groups. The data generated from the data sources described in this chapter will be presented and analysed in the next chapter.

CHAPTER 5

ANALYSIS AND PRESENTATION OF QUANTITATIVE AND QUALITATIVE RESULTS

5.1 Introduction

The previous chapter elaborated on the research methodology, interventions, instruments used for obtaining data, as well as the data sources. To determine the implementation success of the OBE-PBL model as a training strategy of pre-service teachers for an outcomes-based technology curriculum, results are necessary to answer the research questions. The results which were obtained from the variety of data sources will be discussed in this chapter. One of the data sources was the experimental group of learners who were exposed to PBL by the pre-service teachers. The other group was the control group who were exposed to direct instruction methods. These data sets were obtained by means of empirical methods. The other data source was the pre-service teachers themselves who were trained through the PBL strategy and who had to facilitate learning through the PBL strategy. This particular data set was qualitative in nature. The quantitative results will be presented first, followed by the qualitative results.

5.2 Quantitative results

The quantitative data were obtained using four instruments, namely the pre- and post-test, the attitude and LEMOSS questionnaires. These instruments were discussed in Chapter 4 Section 4.4. The following table will summarise the different types of comparisons which were possible between the pre- and post-tests and between the experimental and control groups who wrote the pre- and post-tests:

Control group	Experimental group
Pre-test	Pre-test
Post-test	Post-test

- The pre-test averages of the experimental and control groups were compared.
- The post-test averages of the experimental and control groups were compared.
- The pre- and post-test averages of the experimental group were compared.
- The pre- and post-test averages of the control group were compared.

The results obtained from these comparisons will be presented in the following sections.

5.2.1 Pre-test results comparison between the experimental and control groups

The experimental and control groups wrote exactly the same pre-test. As explained in Section 4.4.1, the pre-test actually served to create two groups of learners who were statistically identical and thus comparable. This means that the two groups did not differ significantly in any of the test questions and therefore not on the test average either. The pre-test, like the post-test, was mainly knowledge-based. The pre- and post-tests were not identical in terms of the questions asked, the formulation or sequence of questions. The pre-test could not intentionally address issues on the technological process and in particularly biogas, because the subjects had not been exposed to it directly prior to the interventions. If learners were given exactly the same test for pre- and post-test comparison purposes, the pre-test could have prepared the experimental and control learners for the post-test to an extent. To avoid this problem, but to enable comparisons to be made between the two groups, it was decided to use the same concepts in the pre-test and post-test, but to formulate the questions in a different way and to change the context in which a particular concept was assessed.

Each question in the pre-test was classified by the researcher according to the cognitive taxonomy of Bloom. The specific cognitive level will be indicated next to each question. The classification of each question was validated by the science and technology teachers who were initially involved in setting the test. The pre-test questions, as well as the Bloom taxonomy level for each question, will be presented below:

Table 5.1: Pre-test: An energy and energy efficiency technology-science test

Pre-test: An energy and energy efficiency technology-science test

Question 1:Cognitive level on Bloom's taxonomy: Knowledge

How would you explain the concept "energy" to a friend? Write this explanation down. (4)

Question 2:Cognitive level on Bloom's taxonomy: Knowledge and comprehension

Should wood be classified as a fossil fuel or a non-fossil fuel? Give reasons for your answer. (4)

Question 3:Cognitive level on Bloom's taxonomy: Knowledge and comprehension

When you switch on the study lamp in your room, not all the electrical energy is transferred into light energy. Use this example to explain what is meant by energy efficiency. (5)

Question 4:Cognitive level on Bloom's taxonomy: Comprehension

On a cold winter's day, your mother's motor car does not want to start because the battery is flat. What type of energy is associated with a motorcar's battery. Why does jumpstarting get the motorcar going again? (5)

Question 5:Cognitive level on Bloom's taxonomy: Application

When a fire brakes out in your classroom, you should not open all the windows, but rather close them all and get out. Explain whether there is sense in this drill and give reasons for your argument. (5)

Question 6:Cognitive level on Bloom's taxonomy: Application

The heater you use in winter is powered by electricity. Select the correct answer:

The amount of heat emitted by the electrical heater is

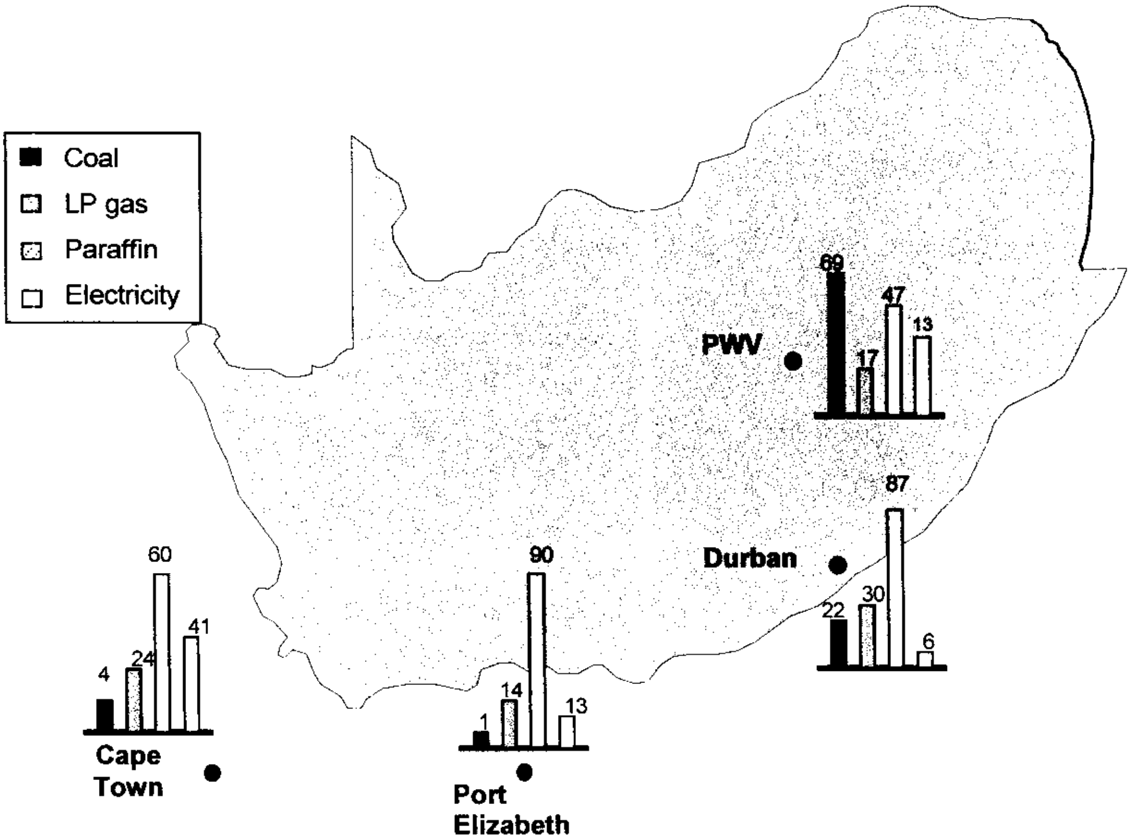
- A) exactly the same as the amount of electrical energy supplied.
- B) less
- C) more

Explain the reasons for your decision. (5)

Question 7: Cognitive level on Bloom's taxonomy: Comprehension

Study the diagram below (Mineral and Energy Policy Centre, 1996:21):

Which of the cities in the diagram is most likely to contribute to pollution? Give reasons for your answer. Remember to consider how electricity is generated before you attempt to answer this question. (5)



7.1 Cognitive level on Bloom's taxonomy: Comprehension

Which of the cities in the diagram is most likely to contribute to pollution? Give reasons for your answer. Remember to consider how electricity is generated before you attempt to answer this question. (5)

7.2 Cognitive level on Bloom's taxonomy: Application/comprehension

Households in rural areas mostly make use of paraffin, which is a by-product from refining oil, for their energy needs. What do you think is the reason for this? (4)

7.3 Cognitive level on Bloom's taxonomy: Application

Calculate the total percentage of electricity users at the coast. Do the same for users of coal. How do these two groups compare with one another? (4)

Question 8:

8.1 Cognitive level on Bloom's taxonomy: Comprehension

Wood and coal may both be used as sources of energy. Explain what the health and environmental effects of these sources are. (3)

8.2 Cognitive level on Bloom's taxonomy: Application

Eight million tons of wood is yearly burnt as domestic fuel in South Africa. What do you foresee will the result of this fact be on South Africa?

What advice will you give to the people using the wood? (3)

8.3 Cognitive level on Bloom's taxonomy: Knowledge

Provide a list of resources which may be considered as substitute resources for wood and coal. (3)

8.4 Cognitive level on Bloom's taxonomy: Knowledge

What do you think will be a good substitute energy resource for wood and coal particularly in South Africa? Give reasons for your answer. (3)

Question 9: Cognitive level on Bloom's taxonomy: Analysis/synthesis

As an energy expert, you are asked to write a brosjure with tips on how to decrease a family's monthly electricity bill in summer and winter months. (6)

Question 10: Cognitive level on Bloom's taxonomy: Analysis/synthesis

Explain to a friend how you will plan and prepare an experiment to show that energy is transferred from one form to another. (10)

TOTAL: 70

P-values, also known as exceedance probability, were calculated to determine whether meaningful differences existed between the experimental and control groups' test averages (Steyn, Smit, Du Tiot & Strasheim, 1996:420). This is the same data table that was presented in section 4.5.2.2 in Table 4.8.The data set had a normal tendency, but was not perfectly normally distributed. Therefore a **Wilcoxon sign rank sum test** was executed for a non- symmetrical data set to determine the exceedence probability (p – value) (Steyn, Smit, Du Tiot & Strasheim, 1996:594 and Keller & Warrack, 2000:513).

Table 5.2: Pre-test results comparison per group

	Pre-test		p-value Wilcoxon sign rank sum test (p-value)
	Mean (X)	Std. dev (s)	
Experimental group N = 70	61,7857	15,7847	0,7990
Control group N = 70	61,8286	15,6899	

The p-value did not indicate a meaningful difference between the experimental and control group averages for the pre-test. This result indicated that the two groups started off on an equivalent knowledge basis prior to any research interventions. There was no significant difference between the experimental and control groups for individual questions. The mean and standard deviation for each question will therefore not be presented. This, however, will be the case with the post-test where significant differences for individual questions were present.

5.2.2 Post-test results comparison between the experimental and control groups

Both the experimental and control groups wrote the post-test after the one month intervention. The post-test was statistically analysed for each question. The experimental and control groups were compared to determine whether a meaningful difference existed between the mean scores of each question and for the test total. P-values were calculated to determine whether meaningful differences existed between the experimental and control groups (Steyn, Smit, Du Tiot & Strasheim, 1996:420).

The experimental and control groups are for statistical purposes regarded as two independent sample populations. This particular data set was tested for symmetry, which it did not have. Therefore a distribution-free test, called the **Mann-Witney rank sum test** was used to calculate the p-values (Steyn, Smit, Du Tiot & Strasheim, 1996:594 and Keller & Warrack, 2000:513). A distribution-free test is not dependent on whether a sample population is normally distributed on the basis of the central limit theorem.

The post-test itself will be presented before the post-test results will be presented. Each question, as in the pre-test, was classified by the researcher according to the cognitive taxonomy of Bloom. The specific cognitive level will be indicated next to each question.

Table 5.3: Post-test: The energy and energy efficiency technology-science test

Post-test: The energy and energy efficiency technology-science test

Question 1: Cognitive level on Bloom's taxonomy: Knowledge

What is energy? Describe it in your own words. (4)

Question 2: Cognitive level on Bloom's taxonomy: Knowledge and comprehension

What is chemical energy? Also give examples of chemical energy resources. (5)

Question 3: Cognitive level on Bloom's taxonomy: Knowledge and comprehension

Describe what you understand by the term "fossil fuels". Give examples of fossil fuels and non-fossil fuels. (5)

Question 4: Cognitive level on Bloom's taxonomy: Comprehension

Most of the chemical energy stored in motorcar fuel (petrol) is not used to move the car when combusted. Most of the chemical energy is transformed into another form of energy, namely heat energy. Use this example to explain the concept of energy efficiency. (5)

Question 5: Cognitive level on Bloom's taxonomy: Application

When you make a fire for some reason or another, such as preparing food or for heat in winter, you sometimes need to help the fire to get going effectively. What would you do to get the fire going? What methods will you use? Explain why you sometimes need to help the fire in this particular way. (5)

Question 6: Cognitive level on Bloom's taxonomy: Application

Electricity is used to light (power) a light bulb. Select the correct answer:

The amount of light energy emitted by the light bulb is

a) more

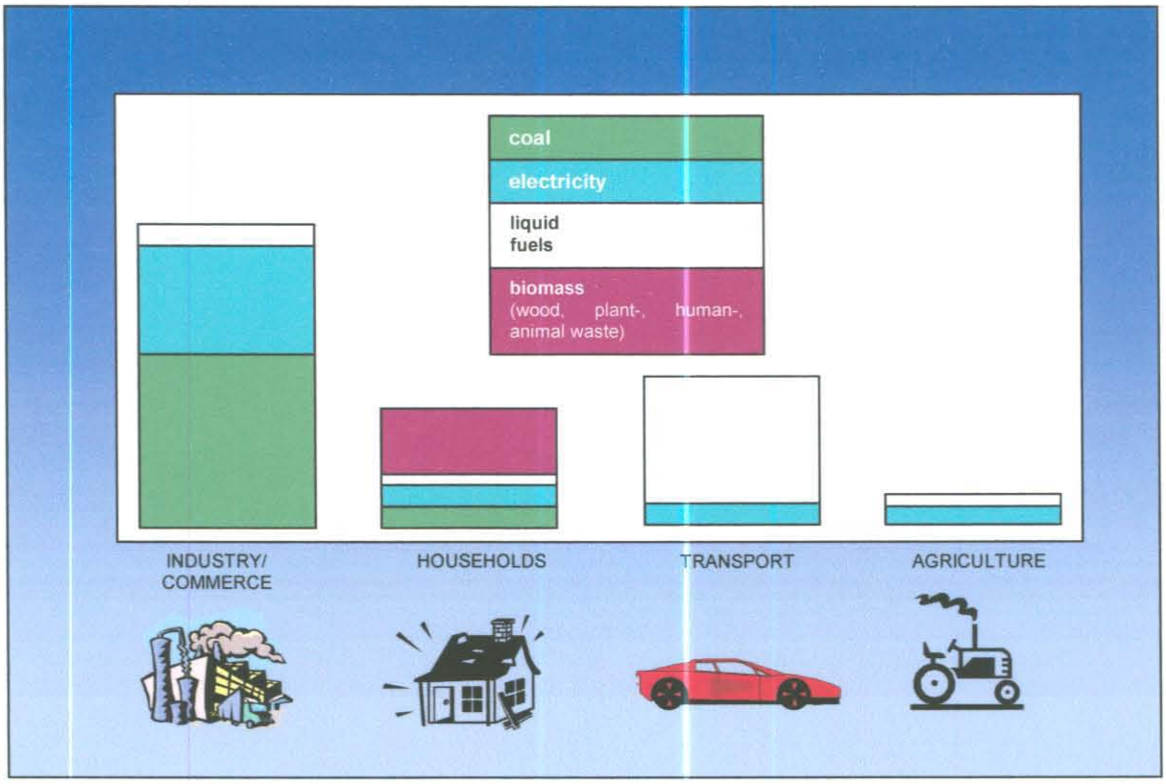
b) less

c) exactly the same as the amount of electrical energy supplied.

Give reasons for your answer. (5)

Question 7:

Study the diagram below (Mineral and Energy Policy Centre, 1996:20):



7.1 Cognitive level on Bloom's taxonomy: Comprehension

Use the diagram to name the energy source which is mostly used by each of the four groups of energy users. (5)

7.2 Cognitive level on Bloom's taxonomy: Application/comprehension

Give reasons why you think a particular resource is mostly used by each of the groups of energy users. (5)

7.3 Cognitive level on Bloom's taxonomy: Analysis

Which of these groups of energy users are most likely to contribute to air pollution? Give reasons for your answer. (5) (15)

Question 8

8.1 Cognitive level on Bloom's taxonomy: Knowledge

Explain what alternative energy resources are and give examples of alternative resources. (3)

8.2 Cognitive level on Bloom's taxonomy: Knowledge

You did a project on energy and energy efficiency. In the problem which you had to solve you had to focus on biogas. Would you classify biogas as an alternative energy resource? Give reasons for your answer. (3)

8.3 Cognitive level on Bloom's taxonomy: Comprehension

Explain what biogas is. Also give a chemical reaction to illustrate how biogas is formed. (4)

[10]

Question 9: Cognitive level on Bloom's taxonomy: Analysis/synthesis

As an energy expert, you are consulted to do an environmental impact study before a factory plant can be built which will produce biogas on a large scale. Advise the interested role players on the following regarding biogas as an alternative energy form:

- The advantages of biogas.
- The disadvantages of biogas.
- The possibilities of biogas.

Use a table format to present your advice (6)

Question 10: Cognitive level on Bloom's taxonomy: Analysis/synthesis

Tell a friend how you will go about designing a model or a prototype for a technological device such as a biogas maker. (10)

TOTAL: 70

Please comment on your personal experience of the new method of teaching which was used for this project:

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Thank you for your participation!

Note: This blank space was left at the bottom of the post-test for learners of the experimental group, to write comments on their experiences of the new method that was used for teaching and learning. These qualitative learner comments will be addressed and related to empirical results obtained from the attitude questionnaire in Section 5.2.6.

The post-test results for the experimental and control groups will be presented in Table 5.4. The results of each question, as well as the test totals, will be given. Next to each question number, the marks allocated to that question will be indicated in brackets.

Table 5.4: Post-test comparison between experimental and control group

	Experimental group		Control group		p-value
	Mean (X)	**Std. dev.(s)**	**Mean (X)**	**Std. dev.(s)**	**Mann-Witney Rank sums**
Question 1 (4)	3,1617	0,7453	3,5362	0,6769	0,0016**
Question 2 (5)	3,2794	0,7697	3,4203	0,8644	0,3895
Question 3 (5)	2,7647	0,9943	3,9420	0,8023	0,0000**
Question 4 (5)	3,3235	0,7811	3,3043	0,8099	0,9170
Question 5 (5)	4,0588	0,8443	2,5797	0,8297	0,0000**
Question 6 (5)	3,3088	0,6749	3,4348	0,7761	0,4282
Question 7 (15)	8,8823	2,2026	9,2319	2,1223	0,3460
Question 8 (10)	5,8235	1,0782	6,0000	1,1882	0,4722
Question 9 (6)	4,5147	1,0147	3,2898	0,8419	0,0000**
Question 10 (10)	6,5441	1,2629	5,1159	0,9631	0,0000**
Test total: Percentage	65,1321	11,5564	62,7244	9,8546	0,2652

** $p < 0{,}01$
* $p < 0{,}05$

For question 1 and 3 the p-values are smaller than 0,01. This means that the higher mean scores of the control group for these two questions are significantly higher than the mean scores of the experimental group. It means that the probability that the difference occurred by chance was less than 1%.

It seems that the direct instruction strategies enhanced performance in these two questions. Both these questions represented the lower cognitive levels of the Bloom taxonomy. These two questions were classified on the knowledge and/or comprehension cognitive levels.

For questions 5, 9 and 10 the experimental group scored significantly higher than the control group. Question 5 was classified under the application cognitive level, while the other two represented the higher cognitive levels in Bloom's taxonomy. It seems that the PBL strategies enhanced performance in these three questions. The **total** test average of 65,13 % of the experimental group is higher than the control group's total test average of 62,72 %. This difference however, is not statistically significant.

5.2.3 Pre- and post-test results comparison per group

P-values were calculated to determine whether a meaningful difference between the pre- and post-test totals existed for each of the experimental and control groups. The data set was tested and showed a normally distributed tendency, but it was not perfectly normal. For statistical purposes the pre- and post-tests are regarded as two dependent sample populations. The distribution-free test which was used for the two dependant sample populations, is called the **Wilcoxon sign rank sum test** (Steyn, Smit, Du Tiot & Strasheim, 1996:594 and Keller & Warrack, 2000:513). This is the oldest and best known of the distribution-free tests according to Steyn, Smit, Du Tiot & Strasheim (1996:594, 589).

Table 5.5: Pre- and post-test results comparison per group

	Pre-test		Post-test		Mean difference between pre-and post-test	Mean Std. dev. (s)	p-value
	Mean (X)	Std. dev. (s)	Mean (X)	Std. dev. (s)			Wilcoxon sign rank sum test
Experimental group N = 70	61,7857	15,7847	65,1321	11,5564	3,2647	9,3019	0,0133*
Control group N = 70	61,8286	15,6899	62,7244	9,8546	1,2029	9,4768	0,6710

** $p < 0{,}01$

* $p < 0{,}05$

The post-test mean score for the experimental group is significantly higher than the pre-test mean score. It can be assumed with 95% (Wilcoxon sign rank sum test) certainty that the

PBL intervention was responsible for the meaningful improvement from the pre- to the post-test. This, however, cannot be claimed for the control group.

5.2.4 Results from the attitude questionnaire

Only the experimental group who had the PBL interventions completed this questionnaire to determine their attitude towards PBL and related issues. Frequency counts for each option and each question were calculated and presented as a percentage.

Table 5.6: Attitude questionnaire for the experimental group

ATTITUDE QUESTIONNAIRE FOR THE EXPERIMENTAL GROUP						
Surname and Name: .... Respondent Number: ...... Encircle the number of your choice.Eg. 1 2 (3) 4 5 **Numbers 1 to 5 have the following meaning:** **1 = not at all** **2 = not too much** **3 = I don't know** **4 = quite a lot** **5 = very much**		**Not at all**	**Not too much**	**I don't know**	**Quite a lot**	**Very much**
1	Did you learn anything valuable from this particular task?	1	2	3	4	5
2	Was the research kit of any help to you?	1	2	3	4	5
3	Did you make use of the research checklist which was part of the kit?	1	2	3	4	5
4	Do you enjoy this new method in the teaching of a subject?	1	2	3	4	5
5	Do you think it is valuable to work in small groups with fellow learners?	1	2	3	4	5
6	Do you prefer to rather work on your own?	1	2	3	4	5
7	Did you have to work hard to execute this task?	1	2	3	4	5
8	This method has helped me to learn how to solve problems.	1	2	3	4	5

Results from the attitude questionnaire

The results from each question in the attitude questionnaire will be summarised in table format. The largest percentage of learners who chose a particular option will be highlighted in the table.

Question 1:Did you learn anything valuable from this particular task?

Response options	Frequency count	Percentage(%)
1	4	4,0
2	15	15,0
3	16	16,0
4	**58**	**58,0**
5	7	7,0

Question 2:Was the research kit of any help?

Response options	Frequency count	Percentage(%)
1	0	0,0
2	2	2,0
3	8	8,0
4	41	41,0
5	**49**	**49,0**

Question 3:Did you make use of the research checklist which was part of the kit?

Response options	Frequency count	Percentage(%)
1	1	1,0
2	7	7,0
3	11	11,0
4	**47**	**47,0**
5	34	34,0

Question 4: Do you enjoy this new method and approach in the presentation of a subject?

Response options	Frequency count	Percentage(%)
1	1	1,0
2	12	12,0
3	11	11,0
4	30	30,0
5	**46**	**46,0**

Question 5: Do you think it is valuable to work in small groups with fellow learners?

Response options	Frequency count	Percentage(%)
1	7	7,0
2	8	8,0
3	11	11,0
4	28	28,0
5	**46**	**46,0**

Question 6: Do you prefer to rather work on your own?

Response options	Frequency count	Percentage(%)
1	23	23,0
2	**26**	**26,0**
3	17	17,0
4	16	16,0
5	18	18,0

Question 7: I had to work hard to execute this task.

Response options	Frequency count	Percentage(%)
1	3	3,0
2	4	4,0
3	14	14,0
4	17	17,0
5	**62**	**62,0**

Question 8: This method has helped me to solve problems.

Response options	Frequency count	Percentage(%)
1	4	4,0
2	13	13,0
3	14	14,0
4	20	20,0
5	**49**	**49,0**

This questionnaire provides results which help to form a general picture of the learners' attitude towards PBL and towards specific elements related to PBL, such as the research kit, meta-learning checklist, and the value and enjoyment related to co-operative learning.

Throughout, the majority of learners selected option 4 (quite a lot) or 5 (very much), which indicates a generally positive attitude towards the particular elements referred to in the questions. The formulation of question 6 however, elicited the selection of option 2 (not too much) as the majority option. It is interesting to note that the results of question 5 and 6 are related. In question five, 46% of the learners indicated that it is very valuable to work in groups, while question 6 indicates that only 23% enjoy it very much to work co-operatively. Throughout all the questions, option 3 (I don't know) was not selected as a majority option. The number of learners who selected this option varied between 11 and 17. These empirical results will later (see Section 5.2.5) be used again when the learner comments are discussed.

5.2.5 The relation between the LEMOSS, achievement and the attitude questionnaire

The Learning and Motivation Study Strategy questionnaire (LEMOSS) was completed by the experimental group after the one month intervention. The function of the LEMOSS was to identify the following attributes and competencies in experimental group learners:

- Level of problem-solving competency.
- Extrinsically motivated learners.
- Intrinsically motivated learners.

Once their problem-solving competency was determined, the experimental group was divided into two groups – one with **low** and the other with **high problem-solving competency**. A strategy had to be implemented which could divide the learners scientifically into the two groups. The LEMOSS was trailed by Basson, Goosen & Swanepoel (1996) with 984 senior secondary learners in public South African schools from the same demographic area as some of the schools which were used in this research. The mean value for the problem-solving category which emanated, was 33,6 (Basson, Goosen & Swanepoel, 1996:62,66). All the learners who scored an average higher than 33,6 were classified as learners with above average (high) problem-solving competency. The same process was used to classify learners with below average (low) problem-solving competency.

The mean values for the categories intrinsic and extrinsic motivation are 16,0 and 15,6 respectively. Where the intrinsic motivation score of a particular learner was higher than the mean intrinsic motivation score and higher than the extrinsic motivation score, that learner was classified as an intrinsically motivated learner. The same principle was applied to identify extrinsically motivated learners.

Apart from the categorisation based on the LEMOSS fields, learners were also categorised, based on their post-test **achievement**. They were divided into two groups, the below average and the above average achievers. Achievement was classified as below average when a score was lower than the post-test average of 65% (rounded off from 65,13%), that is 64% and under. Achievement of 66% and higher was classified as above average achievement. The statistical calculations determined the extent to which these two groups preferred a particular option in the attitude questionnaire.

Once the classification of above and below average problem-solving, intrinsically/extrinsically motivated groups, and below and above average achievers, were completed, analysis with regard to the attitude questionnaire could commence. This particular statistical analysis attempts to determine if any one of these groups had a preference to select a particular option in the attitude questionnaire. Options 1 and 2 in the attitude questionnaire were combined and collectively described as **"not at all"** in the tables below, while option 4 and 5 combined described **"very much"**. Option 3 which is **'I do not know",** is a neutral option. This option was therefore ignored for the Fisher's Exact Two Tail Test, which is only designed to do comparisons in a two by two matrix. The statistical test used, was the Fisher's Exact Two Tail Test.

All the tables, except for two, inform us that the different groups did not have a preference to select a particular option. That means that it was a random phenomena for any of the groups to select any option. Two of the tables however, gave the following information:

Table 5.7: Meaningful differences in achievement: This method has helped me to learn how to solve problems

ACHIEVEMENT: This method has helped me to learn how to solve problems			
• Percentage % • Number of learners	Not at all	Very much	Row percentage
Below average	21,2 (n=15)	27,2 (n=19)	48,4
Above average	8,1 (n=5)	43,6* (n=31)*	51,6
Column percentage	29,3	70,7	100
Fisher's Exact Test (2-tail): 0,025* Right tail value: 0,016* Left tail value: 0,997			

* p < 0,05

The Fisher's Exact Two Tail Test (Fisher, 1935 & Daniel) indicates that significant differences are present in the two by two matrix. The significant differences can be present in rows and/or columns. The right tail test value indicates that the significance lies in one of the two right quadrants of the matrix. The particular extreme value to be identified is the 43,6%. This means that the above average learners have a significant preference to select "very much" for this particular statement in the attitude questionnaire. 31 of the 70 learners who selected the "very much" option, were above average, while only 5 of the above average achievers selected "not at all". In other words, it was significant that six times as many above average achievers indicated that PBL has helped them very much to learn how to solve problems, compared to above average achievers who said PBL did not help them at all in this regard.

Although not significantly different, the below average achievers showed the same tendency in the selection of the "very much" option as the above average achievers. More below average learners, namely 19, also selected the "very much" option compared to the 15 who selected the "not at all option". This however, is not a significant ratio.

Another question which elicited meaningful differences in responses, was whether learners enjoyed PBL as a teaching strategy. The term "method" is used in the question, because learners are more familiar with this term. One would have expected that extrinsically motivated learners and learners with above average problem-solving skills would have a meaningful preference to indicate that they enjoy PBL very much. This was not necessarily the case. The category of above average achievers enjoyed PBL significantly "very much", as shown in the results below:

Table 5.8: Meaningful differences in achievement : Do you enjoy this new method in the teaching of a subject?

ACHIEVEMENT: Do you enjoy this new method in the teaching of a subject?			
Percentage % Number of learners	Not at all	Very much	Row percentage
Below average	25,0 (n=18)	23,5 (n=16)	47,5
Above average	14,5 (n=10)	37,4* (n=26)*	51,9
Column percentage	39,5	60,9	100
Fisher's Exact Test (2-tail): 0,042* Right tail value: 0,046* Left tail value: 0,986			

* $p < 0,05$

The right tail test value again indicates that the significance lies in one of the two right quadrants of the matrix. The particular extreme value to be identified is 37,4%. This means that the above average learners have a significant preference to select "very much" for this particular question in the attitude questionnaire. 26 of the 70 learners who selected the "very much" option, were above average and 10 of the above average achievers selected "not at all". In other words, more than twice as many above average achievers enjoyed learning through PBL, as opposed to the above average achievers who did not enjoy PBL at all. This is a meaningful difference. For the below average achievers, there was not a significant difference between the learners who selected "not at all" and "very much". The number of below average achievers selecting these options are almost the same; 18 below average achievers said they did not enjoy PBL, while 16 enjoyed PBL.

In the rest of the two by two matrixes there were no meaningful preferences present. No particular group had a meaningful preference to select either "not at all" or " very much". In other words, whether a learner is intrinsically or extrinsically motivated, has below or above average problem-solving skills, they do not have particular preferences related to the different questions asked in the attitude questionnaire. The rest of the results are also presented here:

MOTIVATION: Did you learn anything valuable from this task?			
Percentage % Number of learners	Not at all	Very much	Row percentage
Extrinsic	12,1 (n=8)	53,5 (n=37)	65,6
Intrinsic	5,2 (n=4)	29,3 (n=21)	34,5
Column percentage	17,3	82,8	100
Fisher's Exact Test (2-tail): 1,000			

In the row showing the responses of extrinsically motivated learners, it appears that a significant difference should be present for the "very much" option, but it is not. Nearly the same ratio of below average achievers have selected the "very much" option as the above average achievers. This means that five times as many extrinsically motivated learners have selected the "very much" option, while six times as many intrinsically motivated learners have also selected the same option. In other words the two groups exhibited similar preferences in their answers to this question. Therefore, no significant preferences are present in the rows or columns.

In several of the following tables, a similar situation occurs. That is, the ratio of the "very much" to the "not at all" options is high in each row, but because it is similar for the two rows there is no overall significant difference. The tables showing a similar tendency will be presented below. The other tables where there is no similar tendency, will be presented directly after the similar tendency tables.

Tables showing a similar tendency:

MOTIVATION: Did you learn anything valuable from this task?			
Percentage % Number of learners	Not at all	Very much	Row percentage
Below average	11,8 (n=17)	36,8 (n=26)	48,6
Above average	7,4 (n=5)	44,1 (n=31)	51,5
Column percentage	19,2	80,9	100
Fisher's Exact Test (2-tail): 0,3630			

The preferences of the below- and above-average achievers were similar.

PROBLEM-SOLVING: Did you learn anything valuable from this task?			
Percentage % Number of learners	Not at all	Very much	Row percentage
Below average (<33,5)	4,4 (n=3)	16,4 (n=12)	20,8
Above average (>33,5)	14,7 (n=10	64,6 (n=45)	79,4
Column percentage	19,1	81,0	100
Fisher's Exact Test (2-tail): 1,000			

MOTIVATION: Was the research kit of any help to you?			
Percentage % Number of learners	Not at all	Very much	Row percentage
Extrinsic	1,8 (n=1)	64,3 (n=45)	66,1
Intrinsic	0,0 (n=0)	33,9 (n=24)	33,9
Column percentage	1,8	98,2	100
Fisher's Exact Test (2-tail): 1,000			

ACHIEVEMENT: Was the research kit of any help to you?			
Percentage % Number of learners	Not at all	Very much	Row percentage
Below average	0,0 (n=0)	45,6 (n=32)	45,6
Above average	3,1 (n=2)	49,2 (n=34)	52,3
Column percentage	3,1	94,8	100
Fisher's Exact Test (2-tail): 0,493			

PROBLEM-SOLVING: Was the research kit of any help to you?			
Percentage % Number of learners	Not at all	Very much	Row percentage
Below average (>33,5)	1,5 (n=1)	18,5 (n=13)	20
Above average (<33,5)	1,5 (n=1)	78,5 (n=55)	80
Column percentage	3	97	100
Fisher's Exact Test (2-tail): 0,362			

MOTIVATION: Do you enjoy this new method in the teaching of a subject?			
Percentage % Number of learners	Not at all	Very much	Row percentage
Extrinsic	27,6 (n=19)	37,9 (n=27)	65,5
Intrinsic	13,8 (n=10)	20,7 (n=14)	34,5
Column percentage	41,4	58,1	100
Fisher's Exact Test (2-tail): 1,000			

PROBLEM-SOLVING : Do you enjoy this new method in the teaching of a subject?			
Percentage % Number of learners	Not at all	Very much	Row percentage
Below average (<33,5)	7,4 (n=5)	13,2 (n=9)	20,6
Above average (>33,5)	32,4 (n=23)	47,1 (n=33)	79,5
Column percentage	39,8	60,3	100
Fisher's Exact Test (2-tail): 1,000			

MOTIVATION: Do you think it is valuable to work in small groups with fellow learners?			
Percentage % Number of learners	Not at all	Very much	Row percentage
Extrinsic	25,0 (n=18)	41,1 (n=28)	66,1
Intrinsic	14,3 (n=10)	19,6 (n=14)	33,9
Column percentage	39,3	60,7	100
Fisher's Exact Test (2-tail): 0,780			

ACHIEVEMENT: Do you think it is valuable to work in small groups with fellow learners?			
Percentage % Number of learners	Not at all	Very much	Row percentage
Below average	24,6 (n=17)	26,2 (n=18)	50,8
Above average	15,4 (n=11)	33,9 (n=24)	49,3
Column percentage	40	60,1	100
Fisher's Exact Test (2-tail): 0,207			

PROBLEM-SOLVING : Do you think it is valuable to work in small groups with fellow learners?			
Percentage % Number of learners	Not at all	Very much	Row percentage
Below average (<33,5)	7,7 (n=5)	12,3 (n=9)	20
Above average (>33,5)	32,3 (n=23)	47,7 (n=33)	80
Column percentage	40	60	100
Fisher's Exact Test (2-tail): 1,000			

MOTIVATION: Do you prefer to rather work on your own?			
Percentage % Number of learners	Not at all	Very much	Row percentage
Extrinsic	31,0 (n=22)	34,5 (n=24)	65,5
Intrinsic	15,5 (n=11)	19,0 (n=13)	34,5
Column percentage	46,5	53,5	100
Fisher's Exact Test (2-tail): 1,000			

ACHIEVEMENT: Do you prefer to rather work on your own?			
Percentage % Number of learners	Not at all	Very much	Row percentage
Below average	22,1 (n=15)	26,5 (n=19)	48,6
Above average	22,1 (n=15)	29,4 (n=21)	51,5
Column percentage	44,2	55,9	100
Fisher's Exact Test (2-tail): 1,000			

PROBLEM-SOLVING: Do you prefer to rather work on your own?			
Percentage % Number of learners	Not at all	Very much	Row percentage
Below average (<33,5)	10,3 (n=7)	10,3 (n=7)	20,6
Above average (>33,5)	33,8 (n=24)	45,6 (n=32)	79,4
Column percentage	44,1	55,9	100
Fisher's Exact Test (2-tail): 0,764			

MOTIVATION: Did you have to work hard to execute this task?			
Percentage % Number of learners	Not at all	Very much	Row percentage
Extrinsic	7,0 (n=5)	57,9 (n=34)	64,9
Intrinsic	1,8 (n=1)	33,3 (n=23)	35,1
Column percentage	8,8	91,2	100
Fisher's Exact Test (2-tail): 0,647			

ACHIEVEMENT: Did you have to work hard to execute this task?			
Percentage % Number of learners	Not at all	Very much	Row percentage
Below average	6,0 (n=4)	14,8 (n=29)	20,8
Above average	3,0 (n=2)	49,3 (n=35)	52,3
Column percentage	9,0	64,1	100
Fisher's Exact Test (2-tail): 0,414			

PROBLEM-SOLVING: Did you have to work hard to execute this task?			
Percentage % Number of learners	Not at all	Very much	Row percentage
Below average (<33,5)	0,0 (n=0)	20,9 (n=15)	20,9
Above average (>33,5)	9,0 (n=6)	70,2 (n=49)	79,2
Column percentage	9	91,1	100
Fisher's Exact Test (2-tail): 0,330			

MOTIVATION: This method has helped me to learn how to solve problems			
Percentage % Number of learners	Not at all	Very much	Row percentage
Extrinsic	22,2 (n=16)	42,6 (n=29)	64,8
Intrinsic	9,3 (n=7)	25,9 (n=18)	35,2
Column percentage	31,5	68,5	100
Fisher's Exact Test (2-tail): 0,760			

PROBLEM-SOLVING SKILLS: This method has helped me to learn how to solve problems			
Percentage % Number of learners	Not at all	Very much	Row percentage
Below average (<33,5)	4,8 (n=3)	12,9 (n=9)	17,7
Above average (>33,5)	24,2 (n=17)	58,1 (n=41)	82,3
Column percentage	29	71	100
Fisher's Exact Test (2-tail): 1,000			

Tables showing a random phenomena:

MOTIVATION: Did you make use of the research checklist which was part of the kit?			
Percentage % Number of learners	Not at all	Very much	Row percentage
Extrinsic	44,8 (n=31)	20,7 (n=15)	65,5
Intrinsic	15,6 (n=11)	19,0 (n=13)	34,6
Column percentage	60,4	39,7	100
Fisher's Exact Test (2-tail): 0,098			

It is interesting to note that twice as many extrinsically motivated learners *did not* use the checklist compared to the extrinsically motivated learners who did use it. The purpose of the checklist was to stimulate the reflective thinking and meta-learning-abilities of learners. It seems that the extrinsically motivated learners have used one another in the co-operative groups to reflect on ideas – true to the nature of extrinsically motivated learners who derive their stimuli from their external environment. The comments made by the learners will pick up on this idea.

ACHIEVEMENT: Did you make use of the research checklist which was part of the kit?			
Percentage % Number of learners	Not at all	Very much	Row percentage
Above average	30,9 (n=21)	17,6 (n=12)	48,5
Below average	26,4 (n=19)	25,0 (n=18)	51,4
Column percentage	57,3	42,6	100
Fisher's Exact Test (2-tail): 0,337			

PROBLEM-SOLVING: Did you make use of the research checklist which was part of the kit?			
Percentage % Number of learners	Not at all	Very much	Row percentage
Below average (<33,5)	8,8 (n=6)	11,8 (n=8)	20,6
Above average (>33,5)	48,5 (n=34)	30,9 (n=21)	79,4
Column percentage	57,3	42,7	100
Fisher's Exact Test (2-tail): 0,241			

5.2.6 General conclusion: Quantitative results

The most salient results that emerged from this section are the following:

(i) The pre and post knowledge-based test

There were no significant differences between the experimental and control groups' pre-test results. This indicated that the two groups started off on an equal knowledge basis. The post-test revealed that there were significant differences between the experimental and control groups in five test questions. In two lower cognitive questions, according to Bloom's taxonomy, the control group performed significantly better. In two higher and one lower cognitive question, the experimental group achieved significantly higher scores. Although the experimental group had a higher **total test average** than the control group, the total test average of the two groups did not differ significantly.

Although there was no significant difference in the test total between the experimental and control groups, the pre- and post-test comparisons **per group** reveal that the experimental group performed significantly better in the post-test than in the pre-test. This increase may be ascribed to the PBL strategy which was used to operationalise technology education within the OBE framework. This was not the case with the control group.

(ii) The attitude of the experimental learners towards the OBE-PBL experience

A summary of the results obtained from the attitude questionnaire will be given in this section. For each result, learner quotes will be presented. That is, if there were appropriate comments available from the comments data base. Each quote which will be used, will attempt to enrich the empirical data, in that it will give insights beyond empirical numbers. Additional remarks will be made by the researcher about particular issues arising from the learner comments. Learners from the experimental group had an opportunity to write comments directly after they wrote the post-knowledge test. 28% of the learners commented on the content of the problem and solutions to it. 2% of the learners responded with a single word such as "nice", while 9% did not respond with a written comment. The rest, which constitute 61% of the experimental group, did write comments about the new method of teaching and learning which was used for the "project", as they called it. Prior to each comment, it will be indicated whether a learner was a low or high achiever, extrinsically or intrinsically motivated and had below or above average problem-solving skills. The post-test mark obtained by the learner will also be indicated. Some comments may be used under more that one empirical result.

Attitude result 1:

65% of the learners in the experimental group felt that they did **learn something valuable** from the PBL task, while 19% felt they did not learn very much.

Learner comment:

(Mark 40%, below average achiever, extrinsically motivated):

The project was really valuable and fun. Although – we missed a lot of syllabus work during this project and fell behind classes which were not involved in this project.

Additional remarks:

Although this low achiever is concerned about not covering the syllabus, she still evaluates PBL to be "really" valuable and fun. The less structured learning environment, which is characteristic of PBL, is experienced as "a little bit confusing". This learner is still more comfortable with direct instruction and the old paradigm of learning where a teacher should work through the resource materials in a step-by-step fashion with learners. This comment is characteristic of a learner who has not yet made a paradigm shift about what learning is and how it occurs.

Learner comment:

(Mark: 58%, below average achiever, extrinsically motivated, below average problem-solving skills):

I did not learn very much from this project, because the topic had nothing to do with our syllabus.

Additional remarks:

This below average achiever perceives syllabus work, which is purely content-based, to be the only valuable work from which he can learn something worthwhile. It must be remembered that all the tests and exams will only be on syllabus topics and therefore this learner is rightfully concerned about his marks and passing. Currently, progress and promotion is still only based on a learner's quantitative assessment of tests and exams. There are no obvious incentives for this learner to experience learning beyond the regular work and methods.

Learner comment:

(Mark: 70%, above average achiever, extrinsically motivated, above average problem-solving skills):

It can be of great advantage if we can use this method more often in class. This project in particular is very successful. I enjoyed working on this project with my friends.

Additional remarks:

This above average learner seems to have had positive experiences with the PBL task and will even like to use it more often in the classroom situation. This comment supports the two empirical results obtained from the Fisher's Exact Two Tail Test. The empirical results indicated that the above average achievers enjoy PBL and that the strategy has taught them how to solve problems significantly better than the below average achievers. This extrinsically motivated learner also enjoyed co-operative work.

Attitude result 2:

90% of the learners in the experimental group said that the research kit was very helpful, while 2% indicated that it was not very useful.

Learner comment:

(Mark 71%, above average achiever, intrinsically motivated, above average problem-solving skills):

It is good to do something different than the normal, which is to work from textbooks. It is good to focus on nature itself. However, for a project like this, the time must be enough. For this project it was maybe a little bit too short. For the rest there are no complaints.

Additional remarks:

Doing something different seems to motivate this above average achiever. Since PBL demands using more resources than the textbook and a teacher, the learner needs more time to get involved in his research and problem-solving.

Learner comment :

(Mark 55%, below average achiever, extrinsically motivated, below average problem-solving skills):

The presentation of the project was confusing. The teacher must work through the notes with us and help us to study it.

Additional remarks:

A below average learner asks for structure and direct guidance. In other words, he feels safe within the structured environment he became used to over his years of schooling, where a teacher directs most of the learning. This might be expected of learners with below average problem solving skills.

Attitude result 3:

81% of the learners in the experimental group used the research checklist, while 8% did not use it very often.

No applicable comments are available. The Fishers Exact Two Tail test showed that 31 of the 70 learners who did *not* use the research checklist at all, were extrinsically motivated. Only 15 of the extrinsically motivated learners used the research checklist very much. It may be assumed that the extrinsically motivated learners get their stimulus and monitor their progress from the outside environment, such as the co-operative group members. 13 intrinsically motivated learners used the research checklist, while 11 did not.

Attitude result 4:

76% of the learners in the experimental group indicated that they **enjoyed** the "new method and approach" to teaching, while 13% did not enjoy it very much.

Learner comments:

(Mark 58%, below average achiever, intrinsically motivated, above average problem solving skills):

I think it is very nice and I enjoy it to do things on my own every now and then. One do not only sit on your chair and write frantically like a zombie. I enjoy it.

Additional remarks:

Where the Fisher's Exact Two Tail Test showed that the majority of below average achievers did not enjoy PBL, this particular below average achiever did enjoy working on his own now and then, and especially the fact that he was not treated like a "zombie".

Learner comments:

(Mark 69%, above average achiever, intrinsically motivated, below average problem-solving skills):

I really enjoy these hands-on technology projects. It places science in a new, different light.

Additional remarks:

The learner's reference to hands-on projects indicates that PBL stimulated the learner and involved activity-centred learning experiences which this learner enjoyed. The PBL technology experience seems to have motivated the learner, since he sees science in a new light.

Learner comments:

(Mark 30%, low achiever, intrinsically motivated, below average problem-solving skills):

I do not like it. You waste valuable academic time, which my parents are paying for. We wasted time with senseless group debates. Just give us our books and let us learn.

Additional remarks:

This was one of the lowest achievers in the post-test. This learner begs for direct guidance and structure. He felt very lost in the PBL environment and consequently did not like the PBL experience. This comment also proves that this particular learner who will finish school in two years time, has not been prepared by the schooling he received for the real life roles he will have to demonstrate after school. The particular critical outcome related to solving problems using critical and creative thinking, which was addressed by this PBL task, does not seem to be cultivated by the traditional approaches this learner is comfortable with. His dislike is portrayed as a type of aggression.

Maybe if the pre-service teacher was aware of this, he/she could have given more direct support emotionally and also with the solution of the problem. It seems that a pre-service training programme for OBE-PBL should make pre-service teachers competent to proactively diagnose potential problems, such as this one, especially if the learning challenge is very different from what learners became used to over their years of schooling.

Note: One would expect high achieving, intrinsically motivated, good problem solvers to enjoy PBL and find it valuable. There was not a particular quote from a high achieving, intrinsically motivated learner with above average problem-solving skills to support this expectancy. One female from these categories did however said that *"it was a nice challenge".*

Attitude result 5:

74% of the learners in the experimental group experienced **co-operative work as valuable**, while 15% did not agree.

Learner comments:

(Mark 50%, low achiever, extrinsically motivated, below average problem-solving skills):

It was a good attempt to get children to work together and to get them to think on their own.

Additional remarks:

Although this learner is a below average achiever with low problem-solving skills, she also experienced or suspects that PBL, as it was facilitated by the pre-service teacher, can contribute towards learners thinking on their own, as well as working together.

Learner comments:

(Mark 30%, low achiever, intrinsically motivated, below average problem-solving skills):

We wasted time with senseless group debates.

Additional remarks:

This comment indicates that the PBL task as facilitated by this pre-service teacher, achieved exactly what it aimed to achieve. That is lively debates which forced learners to think critically and meta-cognitively about what they were actually suggesting and why they were suggesting it during the problem-solving process. The fact that this below average learner is intrinsically motivated, might contribute to her not feeling very comfortable learning in a co-operative group. This, however, is a real life role that she should get practice in and although she cannot see the "sense" in the group debates, she will hopefully unconsciously have been prepared or sensitised to an extent for life beyond the grade 10 curriculum.

(Mark 59%, below average achiever, extrinsically motivated, below average problem-solving skills):

This method does not work effectively, because people do not work together in a group. One person has to do everything. Learners who were suppose to gather particular information did not bring it to all group members. If our general knowledge was better, our project also would have worked better.

Additional remarks:

This learner seems to attribute the ineffectiveness of the method to learners not working effectively in a group, rather than the fact that learning is organised around problems. It should also be kept in mind that learners have never done serious learning in a co-operative setup which has to adhere to very specific criteria. The most they have done in groups, not co-operative learning groups, were practical sessions where five or six learners stood at the same working bench when doing an experiment. One or two normally executed the recipe like procedures of the experiment, while the others tried to write down observations or results. They are not used to working together in a constructive manner, where each co-operative member takes responsibility for his or her particular task and to solve cognitive or social conflict productively. It seems that the traditional schooling they became very used to in their ten years of schooling did not really prepare them to cultivate the critical outcome which deals with working together **effectively** as a member of a team. The PBL task with its associated co-operative learning strategy, did challenge the learners to start working effectively in teams. The last comment on general knowledge also indicates that this learner was led to reflect on his and his groups' cognitive resources.

Attitude result 6:

It is interesting that while 74% of the learners in the experimental group find co-operative work valuable, only 49% of the learners in the experimental group **enjoy working in co-operative groups** and 34% do not enjoy working in co-operative groups.

Learner comment :

(Mark 70%, above average achiever, extrinsically motivated, below average problem-solving skills):

It is enjoyable to work in a group, but can be confusing. We missed out on work and consequently we will not cover the syllabus. The result will be bad marks.

Additional remarks:

It is not surprising that an extrinsically motivated learner enjoys co-operative work. Since this leaner is an above average achiever, she is typically concerned about not covering the content-heavy syllabus on which she will be examined. It seems that learning is driven by an achievement approach and not an internal locus of control or deep approach to learning. In an achievement and competition driven society, where best achievement is awarded by extrinsic means such as bursaries and trophies at the end of the year, it is not surprising that content coverage and good marks are the major motivators for this above average learner.

Learner comment :

(Mark 30%, low achiever, intrinsically motivated, below average problem-solving skills):

We wasted time with senseless group debates.

Additional remarks:

It makes sense that an intrinsically motivated learner is not very comfortable with co-operative work, even more so because it is something new to the way in which he is used to learning in class. The purpose of the SAQA critical outcome, which focuses on working together as a member of a team, is to prepare this learner in school for real-life outside of school where he will have to help groups or teams to "make sense" when engaging in debates.

Attitude result 7:

79% of the learners in the experimental group indicated that they **had to work very hard** to execute the task, while 7% said that it was not necessary to work very hard to execute the task. Fisher's Exact Two Tail test showed that *all* the learners with below average problem-solving skills indicated that they had to work very hard, while 70% of the above average problem-solvers also indicated that they had to work very hard. Only 9% of the learners with above average problem-solving skills said they did not have to work hard. The same tendency occurred with the extrinsically and intrinsically motivated learners and with the above and below average achievers. (See Section 5.2.4).

Learner comment :

(Mark 52%, below average learner, extrinsically motivated, below average problem-solving skills):

The method is fine, we just need a little bit more time for all the research. A job done in a rush, is a job half done.

Additional remarks:

Various reasons may be given for why the learners said that they really had to work very hard and that that they needed more time. First, PBL is learner-centred and engages learners actively in their learning process. What the learners had to do to solve the problem involved much more time and effort than using a textbook, answering end-of-chapter questions, executing pre-designed experiments and designs. The PBL design provided them with no opportunity to be passive and to transfer the responsibility for their own progress to the teacher. The teacher of course, always remains responsible for the progress in the learning process as was explained in Section 3.2.1. Secondly, the learners from the experimental group did not receive the problem-solution, with an appropriate design in a pre-packed format. The nature of the PBL task was open-ended and they had to brainstorm points of departure and possible solutions. They finally had to do more with their theoretical suggestion for an effective solution – they had to make their ideas work by building a prototype, model or the final device. Thirdly, the PBL and co-operative practice were new to them. They had to become familiar with a few unfamiliar practices. These reasons might contribute to the fact that they had to work hard to execute the task and to the fact that more time would have come in handy for them.

This comes as no surprise, since learning through PBL takes more time than learning the same content and skills through direct instruction. More time could have been provided, seeing that learners were not familiar with PBL and its associated strategies. The duration of the school practice period at this particular university is one month (20 school days). This intervention with the experimental group took up the whole month.

Learner comment :

(Mark 72%, above average achiever, intrinsically motivated, above average problem-solving skills):

I do feel that more time can be allocated for the project.

Attitude result 8:

69% of the learners in the experimental group indicated that the PBL method has **helped them to learn how to solve problems**, while 17% feel that it did not help them very much in this regard.

Learner comment :

(Mark 72%, above average achiever, extrinsically motivated, above average problem-solving skills):

The project was interesting. It was something new. You do not have to learn everything like a parrot. It is nice to do things and practical work on your <u>own</u>. You get to work with something that you don't know at all and get to know it through your involvement.

Additional remarks:

This learner is an above average achiever and feels empowered by the fact that he could work on his own and not in a prescriptive, parrot-like fashion. The challenge engaged him to such an extent that he requires more time. It seems that this PBL task has motivated this particular learner both intrinsically and extrinsically.

Concluding remarks

The learners' experiences of PBL and its related strategies reflect varying attitudes, some more negative and the majority more positive. The selected learner comments add richness to the empirical data, in that they provide insight into specific empirical responses. One of the constants coming to the surface is that both below and above average achievers have asked for more time to be engaged in the PBL task. It seems that learners realise that to be successful in PBL, they need to be engaged in depth with the issues and particularly resources related to the problem. Actually, the nature of PBL demands this involvement and commitment from learners. The one month period, with six to seven thirty minute periods per five day school week, did not seem to be enough time. Learners who were very successful with the execution of the PBL task, did put in a lot of extra effort in their own time after school.

Although the majority of learners had positive attitudes, reasons must be found to determine why some had negative attitudes. Some of the comments showed that certain learners did not like working co-operatively, although they valued it. Others were not comfortable in the less-structured learning environment created by PBL. They still want learning to be teacher-centred and textbook driven methods with which they are familiar. The majority felt empowered by the responsibility and active learner-centred approach to learning. The negative attitudes might not only be attributed to PBL and its associated strategies, but also to the fact that learners were concerned about falling behind other classes, which could result in bad test and exam marks. It is interesting to note that very low and very high achievers had the same concerns in this regard. This is the reality and a problem to be dealt with when doing research in real organisations such as schools. These are also the concerns of principals, teachers and governing parent bodies, which sometimes hinder research where it really matters – in authentic situations with multiple complexities. Also see Section 4.5.2.1 for more reasons why principals did not allow this research to be undertaken in their schools.

(iii) The Fishers Exact Two Tail Test:

The above average achievers had a significant preference to select the “very much” option to the following two questions/statements:

- This method has helped me to learn how to solve problems.
- Do you enjoy this new method in the teaching of a subject?

For the rest of the questions, the below and above average achievers and problem-solvers, as well as the extrinsically and intrinsically motivated learners, did not have a particular preference for or against PBL and its associated strategies. What is worth noting, is that all the categories of learners indicated overwhelmingly that they really had to work very hard to execute the PBL task. This may have been a function of the particular PBL task – it is not necessarily an indication that learners would always have difficulty with PBL. However, the fact remains that the nature of this PBL task and PBL in general, engages learners in high levels of activity and responsibility.

5.3 Qualitative results

Qualitative data were obtained from the six pre-service teachers who voluntarily opted to implement the OBE-PBL model in real classrooms for one month. Prior to their PBL training, these teachers reported in writing on their conceptualisation of technology, technology education and effective teaching strategies for this learning area. After their PBL training on how to facilitate learning in technology from an OBE framework, and their one month experience in practice, they were interviewed. They also kept log-books of their day-to-day activities, experiences and reflections on their teaching practice. The data from the pre-intervention questionnaires, post-intervention interviews and log-books, will be analysed, coded and the results presented in the following sections.

5.3.1 Method of qualitative data analysis

When it comes to qualitative data analysis, much has been described and prescribed by experts in the field. Poggenpoel (1998:337) however, says that "*there is no right or wrong approach to data analysis in qualitative research*". Although there is no single blue-print for qualitative data analysis, there are, however, proven guidelines and strategies which may be utilised by a researcher.

A process of coding described by Bogdan & Biklen (1992: 166-167) and Modingwa (1995: 26-27) has been used as a guideline for developing the coding scheme. While reading through the data the reasoning strategies called "bracketing" and "intuiting" have been applied.

Burns & Grove (1987:80) explain that to bracket, the researcher "*suspends or lays aside what is known about the experience being studied*" so that an open context can be achieved. In other words all preconceived ideas are placed between brackets. Intuiting normally takes place after bracketing to get a sense of the whole (Modingwa, 1995:26). Burns & Grove (1987:80) explain intuiting as

- *... the process of actually 'looking at' the phenomenon....This is thought to allow an increase in insight. Intuiting requires absolute concentration and complete absorption with the experience being studied.*

Video tape recordings of the classroom interventions also exist for selected parts of the PBL training of the pre-service teachers, as well as for their practice interventions. Due to practical circumstances, video recordings were not made of all the pre-service teachers. It was therefore decided not to analyse and code the video clips, but they were used for the purpose of intuiting to get a **holistic** impression before and after the other qualitative data were analysed and coded.

After the researcher familiarised herself with the qualitative data sets and applied the strategies mentioned previously, the task of developing a coding scheme had to start. A coding scheme consisted of code categories and sub-code categories. Although different software programmes such a ATLAS/ti exist, which can assist in the development of a coding scheme, the actual coding and the analysis of the data, it was decided to do the coding and analysis manually. The number of respondents and the data generated by them in this research, were manually manageable. The ATLAS/ti software is particularly useful when an unstructured or open instrument is used to generate data. All the instruments used to gather data in this research were semi-structured. This meant that prominent coding and sub-coding categories were already present in the instruments before the data analysis started.

The first codes were generated from the conceptual framework of the researcher and deduced from the questions which were present in the pre-intervention questionnaire and the post-intervention interview schedule. The researcher was also open to other code categories, which might emerge from the meaning constructed by the respondents (Poggenpoel, 1998:338). These code categories emerge when certain phrases, behaviours, events and ways of thinking repeat themselves to represent a pattern (Bogdan & Biklen, 1992:166).

The code categories were labelled with numbers (eg. 1, 2,..). The need arose to also identify sub-code categories which were labelled as 1.1, 1.2, etcetera. It must be mentioned that some units of data were coded with more than one code or sub-code category.

After the coding scheme was finalised the data were coded by the researcher. The following code categories were identified:

- **Code 1:** Perception of technology and technology education prior to the training intervention.

- **Code 2:** Perceptions and conceptions of technology and technology education after the training intervention.

- **Code 3:** Pre-service teachers' experience of PBL training.

- **Code 4:** Pre-service teachers' experience with PBL in practice.

- **Code 5:** Pre-service teachers' perception of outcomes-based education after the PBL training and practice experience.

The sub-codes which are related to each of the codes will be presented when the qualitative results are discussed.

5.3.2 Results: Perceptions of pre-service teachers prior to the PBL training intervention

The first set of qualitative data was obtained from written opinions and perceptions from the pre-service teachers before the problem-based training for technology education started. Since none of the prospective teachers had any experience of teaching at the beginning of the year when their professional studies in senior secondary education commenced, no pre-perceptions regarding education related issues were determined. It was therefore not established whether the pre-service teachers had a common understanding of OBE or whether they had similar levels of teaching expertise. An exercise if this nature would have been irrelevant for the pre-service teachers. What was established will be discussed in the following section.

All the pre-intervention opinions and understandings regarding technology, technology education and appropriate teaching strategies were established. These pre-intervention perceptions will be represented by code 1. It is therefore labelled as "Perception of technology and technology education prior to the training intervention". Each of the six questions in this open-ended questionnaire represents a sub-code which will be indicated next to the question in Table 5.7 below. No additional sub-codes came to the fore. Pre-service teachers responded to each of these questions and their responses will be coded with one or more of the sub-codes. The following table shows the questions and the sub-codes which were derived from each question:

Table 5.9: Code 1: Perceptions of technology and technology education prior to the training intervention

Code 1: Perceptions of technology and technology education prior to the training intervention	
Questions	**Sub-codes**
What is technology? Explain	1.1: Perception of technology
What is technology education? Explain	1.2: Perceptions of technology education

Is there a difference between technology and natural science?	1.3: Difference between technology and natural science
What is the most effective methodology for the teaching of technology?	1.4: Effective methodology for teaching technology
What are the phases in the technological process?	1.5: Phases in the technological process
Do you think that South African education is ready to implement technology?	1.6: SA readiness for implementing technology.

Results obtained from the qualitative data will be presented in a narrative format, with reference to specific quotes where it contributes to strengthening an argument. Typical answers and remarks recurring frequently will also be presented as quotations. A typed copy of the pre-service teachers' written comments is attached as Appendix 6.

Results of Code 1: Perception of technology and technology education prior to the training intervention

Sub-code 1.1: Perceptions of technology

Technology was broadly described by pre-service teachers as progress, new developments and discoveries through research, which makes life easier, better and simple. Five pre-service teachers described technology as computers, software and electronic equipment which may be used to enhance the quality of products. One pre-service teacher did not attempt to explain what technology is, but gave the following answer:

- *Personally I don't believe that there is one person who can give an exact definition of technology. For me the word has a very broad meaning. I tend to think about computers and all the modern electronic equipment. However, I know that technology is much more than that.*

Sub-code 1.2: Perceptions of technology education

The majority started their answers by saying the learners should be exposed to modern technology such as computers, which the learners will need in their lives. Two said that technology education should be more than exposure, but that learners should get the opportunity to make their own equipment and improve on existing ones.

The notion that technology is associated with a process was also mentioned twice:

- *... it is about teaching them the processes which should be used to discover equipment for themselves and to improve on it.*

- *It is the facilitation of skills which learners have to learn to apply in technology, as well as developing a thinking process where learners have to think beyond the here, now and the known.*

Sub-code 1.3: The difference between technology and science

Four of the six pre-service teachers feel that there is a difference, but that these areas are also inextricably linked. A typical comment is given:

- *Natural science studies the natural laws (etc) and theories ... technology is where certain aspects of science are implemented in practice.*

The idea of technology as applied science is highlighted by the following two quotations:

- *Technology rather focuses on the utilisation possibilities (and the production of products) of basic science understandings and concepts.*

- *Scientists do the research to develop basic knowledge which engineers then can use to design, develop, produce and improve ideas.*

Sub-code 1.4: Effective approach or method for teaching technology

Although none of the pre-service teachers had any experience in technology and no experience in teaching at the beginning of the year, they voiced their opinions and suggestions in this regard. The suggestion that technology should be practically taught, was embraced by four of the pre-service teachers. Here are two of the comments by the pre-service teachers:

- *Technology is a very practical subject and...... learners will have to think for themselves.*
- *Practical investigations and experiments by learners, but especially research by the learners themselves about the latest technological developments. Teaching has to be done by someone who knows enough and who is interested in the subject, else it would only be another dead subject.*

Sub-code 1.5: Phases in the technological process

The majority, which comprise five pre-service teachers, said that they did not know what the phases of the technological process are. One speculated that it was maybe the same as the steps in the scientific process:

- *Maybe it is like the scientific process of hypothesising, experimenting (repeat and accurate). Verify or reject the hypothesis, formulate a theory and finally produce a final product.*

One of the pre-service teachers came very close to the technology process as it is conceptualised in South African curricula:

- *I don't know, maybe it is: identify a problem, find a solution, test, evaluate and implement – it actually is the same steps which engineers use.*

Sub-code 1.6: SA readiness for implementing technology

Pre-service teachers who said that South Africa is not ready to implement technology, ascribe it to the lack of funds, lack of adequately qualified and trained facilitators and minimum facilities. As one said : *"There is not even enough money to buy text books. In private schools where funds are available, it will work"*. One did mention that the lack of resources is not supposed to be a limiting factor because *"the whole subject is about solving problems!"*.

Two pre-service teachers remarked that South Africa is ready:

- *Yes, I think we have the necessary facilities and competent people to teach such a subject.*
- *SA has a lot of potential, but not the necessary funds to keep up with first world countries. If it's not about money, Yes.*

These results, which were obtained before the training, will later be compared with results obtained after the training and practice experiences of the pre-service teachers.

5.3.3 Results from the interviews with the pre-service teachers and their log-books.

The interviews were conducted by the researcher after the training and practice intervention, when the pre-service teachers had enough time to reflect on their experiences. Appropriate extracts from the daily kept log-books will be used when applicable. The translated transcripts are included as Appendix 7.

Two of the pre-service teachers who worked as a team at one of the schools asked to be interviewed simultaneously. Since they did form an effective team in the same school, the request was granted. The other interviews were conducted on a one-to-one basis. The main codes which were used for analysing the interviews are:

- **Code 2:** Perceptions of technology and technology education after the training intervention.

- **Code 3:** Pre-service teachers' experience in PBL training.

- **Code 4:** Pre-service teachers' experience with PBL in practice.

- **Code 5:** Pre-service teachers' perceptions of outcomes-based education after the PBL training and practice experience.

Results of Code 2: Perceptions of technology and technology education after the training intervention

Three sub-codes emerged from the interview data for code 2, which are presented in the Table 5. 8 below:

Table 5.10: Code 2: Perceptions of technology and technology education after the training intervention

Code 2:	**Perceptions of technology and technology education after the training intervention**
Interview question: How would you explain to a parent or fellow student what technology education is?	
Sub-code 2.1:	Problem-based perception
Sub-code 2.2:	Process perception
Sub-code 2.3:	Creative challenge

Sub-code 2.1: Problem-based perception

The initial perception which was held by many pre-service students that technology education is merely about exposing learners to computers and other high-tech equipment, which they will need in their lives, was not mentioned once. The perception that technology is focused towards the identification and solution of problems and needs was a popular one:

- *It teaches learners how to think to solve problems.*
- *To teach children to identify problems, to look for solutions, to produce a product or system and to evaluate it. Technology is need-driven.*

Sub-code 2.2: Process perception

Pre-service teachers continued to explain that the solution of a problem involves more than just a final product or system as outcome. They describe and value the process of getting to the solution. One pre-service teacher said that the processes involved in technology education might even help learners to develop generic skills which they might find useful in their lives.

- *He has to recognise a problem, seek a solution, design and make and finally evaluate the end product. In the process he learns an enormous amount of skills during the resource tasks, which will help him to develop into a useful person.*
- *I still think it is not only about products, but about a thinking process.*

Sub-code 2.3: Creative challenge

The following two pre-service teachers experienced technology as a learning area which enhances creative endeavours:

- *Well, in technology education, like in science education learners have to discover and explore on their own. In technology education they have to design and make their own ideas – they are not given a design to just copy and make.*
- *Finding solutions to problems, is something that cannot be given – the*

individual has to look for it by doing thorough research.

Results of Code 3: Pre-service teachers' experience of PBL training

Table 5.11: Code 3: Pre-service teachers' experience of PBL training

Code 3:	**Pre-service teachers' experience of PBL training**
Interview question: How did you experience the problem-based approach in your training?	
Sub-code 3.1:	PBL as a valuable learning experience – ascribed to its practical nature
Sub-code 3.2:	PBL as an unstructured approach
Sub-code 3.3:	PBL experienced as learner-centred and resource-based with high levels of activity
Sub-code 3.4:	PBL experienced as co-operative learning
Sub-code 3.5:	PBL experienced as inducing creativity
Sub-code 3.6:	Other application possibilities of PBL

The sub-codes give an indication of the breadth of the pre-service teachers'experiences with PBL.

Sub-code 3.1: PBL as a valuable learning experience – ascribed to its practical nature

Four pre-service teachers experienced PBL as a very valuable learning experience, although it was different from what they were used to in their previous university experiences in their under-graduate studies. The following quotations will highlight what it is that the pre-service teachers value about their PBL training:

- *I like new things, I liked it very much. Yes, this was the one subject in which I have learnt the most in the whole year. Exept for learning how to design lesson presentations, I also learnt a lot about the subject which I will teach as well.*

It seems that pre-service teachers contribute the value of PBL to what they experienced as the practical, hands-on nature of it. They also mention what PBL intends to achieve with learning – that is to make it more relevant which will enhance the transferability of competence to the work place and every day lives.

- *I feel that this training was very practically orientated and relevant and it is this fact which made the course successful. I have personally grown and I believe so have my fellow students.*

- *Wow – it was really different to what we were used to – but subject didactics is supposed to be more practical than our formal lectures. And it was really practical orientated.*

The two pre-service teachers who worked as a team highlighted the fact that PBL was instrumental in helping them to bridge the gap between knowledge acquisition and the ability to apply it:

Interviewer: *Did the PBL approach help in any way?*

Pre-service teacher A: *Well yes, technology and OBE is all about using your knowledge and by giving us problems, we learn how to apply our own knowledge.*

Pre-service teacher B: *I don't think we know enough about technology education but at least we know something about the methodology of teaching it.*

Interviewer: *What is that methodology?*

Pre-service teacher A: *Well that learners must do their own research and set-up their own experiments if they want to investigate something.*

Sub-code 3.2: PBL as an unstructured approach

Just like some of the learners, one pre-service teacher experienced PBL as an unstructured or ill-structured approach to teaching and learning. This pre-service teacher prefers a highly structured learning environment and says that PBL will work in a subject-didactics class, but not for all subjects. Unfortunately she does not provide a reason for her intuitive opinion.

Pre-service teacher:	*Mm – I think at first I found it a loose approach. I am one of those people who like structure.*
Interviewer:	*Briefly explain what you mean by structure?*
Pre-service teacher:	*I guess I like well organized presentations. I must say that I use the word presentation rather than lecture because it fits better into this new stuff. We also don't prepare "lessons" anymore but learning opportunities.*
Interviewer:	*(Yes) tell me more about your training experience.*
Pre-service teacher:	*I didn't know anything about technology – at least I understand technology better now and that technology is all about solving some needs of society and that is why you gave us all the (unclear on tape) … I mean problems to solve.* *I don't think that all subjects can be presented like this, but it will work in a subject didactics class.*

Sub-code 3.3: PBL experienced as learner-centred and resource-based with high levels of activity

Three pre-service teachers commented on the fact that PBL actually compelled them to become actively involved in the learning process. The activity-based experiences can be related to the various stages and activities associates with PBL. One of the compulsory stages is the research phase, where they had to access and utilise information resources while trying to generate solutions to the posed problems. This research seems to have achieved the outcome of getting pre-service teachers to read extensively and to motivate them to put extra effort in. Three pre-service teachers reported the following:

- *It kept us very busy because we couldn't find all the answers of what we were suppose to do in textbooks – because you didn't prescribe any.*
- *All the extra effort I had to put in looking for relevant problem settings forced me to look beyond textbooks.*
- *For the problems which we had to do first, before one went to the schools, I actually landed up in the Department of Biochemistry. I had some valuable discussions with lecturers there which broadened my horizons.*

During one of the problem-based sessions, they discovered the Teachers' Library in Pretoria, which is valuable resources centre available to all registered South African teachers. At this resource centre they can access information in the form of video's, films, computer software, internet addresses, wall charts, professional transparencies, books, popular and refereed journals which they may use in their future problem-designs as well.

Sub-code 3.4: PBL experienced as co-operative learning

Being final year students busy with a post-graduate professional diploma in secondary education, they should have been well aware of the criteria and advantages of co-operative learning. In general the pre-service teachers report very positively about their experiences with co-operative learning. They mention that what they have experienced as very valuable in co-operative learning is brainstorming, dividing responsibilities among one another and the opportunity to practice the social skill of learning to work with fellow learners. This is however, also one of the seven SAQA critical outcomes in OBE. They had the following to say about their experience of co-operative learning:

Pre-service teacher A: *Well I am glad that you divided us into groups to do the tasks.*

Interviewer: *Why?*

Pre-service teacher A: *It makes a big task like this much easier and we know all the benefits of group work.*

Interviewer: *What are they?*

Pre-service teacher B: *We brainstorm – the more ideas, the better. We share the research work amongst ourselves, and we learn how to work with fellow students. That's why "A" and I decided to do the project together at High School C.*

One pre-service teacher associated continuous assessment with co-operative learning. She valued the immediate feedback provided by co-operative members. This comment strengthens the argument that co-operative learning is a strategy which may be used to stimulate meta-learning and critical thinking skills:

- *By means of co-operative learning we could assess one another on a continuous basis, and we received valuable ideas and information from one another.*

Sub-code 3.5: PBL experienced as inducing creativity

One pre-service teacher felt that she was challenged to be creative when designing problem-based learning tasks in technology education. It is ironic that she did not have this experience intentionally in any of her former studies. It should be remembered that she was in her 16^{th} year of official learning (12 years of school, 3 years for her BSc degree, 1 year for her post-graduate professional teaching diploma) in her life:

- *At the beginning of the year I could not think creatively at all, because it was never necessary to be creative. Your approach has challenged me to develop my creative thinking to such an extent that I can think diverse about problems and solutions.*

Sub-code 3.6: Other application possibilities of PBL

Two pre-service students indicated that PBL has training possibilities for the other Learning Areas as well, while one pre-service teacher felt that it was not the case:

- *Finally I think that this approach will not only work for technology, but for many other subjects as well.*

Another pre-service teacher however, did not share his peers' opinion:

- *I don't think that all subjects can be presented like this, but it will work in a subject-didactics class.*

Results of Code 4: Pre-services teacher's experience with PBL in practice

Table 5.12: Code 4: Pre-services teacher's experience with PBL in practice

Code 4: Pre-services teacher's experience with PBL in practice
Interview question: Part 1: How did the learners experience the PBL approach? Think of your classroom experiences. Part 2: Tell me more about how you facilitated the PBL in practice.
Sub-code 4.1: Learner attitudes
Sub-code 4.2: Problems experienced by learners and pre-service teachers
Sub-code 4.3: The learners' experience of co-operative learning
Sub-code 4.4: Quality of learning

Sub-code 4.1: Learner attitudes

The pre-service teachers experienced the initial attitude of learners as one of excitement and enthusiasm. This attitude changed somehow when the learners realised that they really had to put some effort in to solve the problem. Three of the pre-service teachers report as follows about learner attitudes:

- *In the beginning they were very enthusiastic because it was something new and different. (But) after three weeks the enthusiasm of some faded, because they realised it was not just a play-play task. The time came closer to demonstrate their energy devices.*

- *Learners were exited about the whole thing after they were presented with the problem. They have asked to work in groups themselves and the class was divided into four groups with five to six learners per group.*

- *Some of them thought it was playtime because they didn't have formal lessons. For some of them the idea of doing the whole task as a group was the greatest attraction of the whole thing.*

In the last phase of the project, the learners presented their technological energy devices to a "board of experts from The Department of Minerals and Energy". In her log-book one teacher wrote that one of the groups showed a negative attitude when they refused to do the presentation due to being unprepared on the day of their final solution presentation. She mentioned that this all-boys group was one of the groups who thought that the non-formal structure of PBL learning environments meant play time and socialisation with co-operative team members. They said that *"they did not prepare and that they only want to write the test to finish this whole project off"*. Learners will also have to take up their responsibility and must show accountability in a learner-centred environment created by PBL. This however, will not come instantly for learners who also have to make a paradigm change about alternatives for effective teaching and learning.

In the following scenario the positive attitude of the pre-service teacher seemed to rub off on to all partners involved in the PBL learning experience. The pre-service teacher who arranged a coal mine field trip in Ellisras, experienced the practice situation as follows:

- *Personally I think that the learners in this school have gained very much from this whole project. The problem forced them to use different resources, apart from the kit they received. I know that we had to do the same things in the different schools, but I decided to arrange a field-trip to a coal mine where they could see energy and technology in action. My husband is an engineer there, so it was quite easy to organise it. I thought if other schools could use internet as an extra resource, I can use the coal mine experience as an extra resource.*

- *The principal liked the idea so much that he said he would appreciate it if the whole grade 10 science group could go. I received so much support from the principal and the science teachers. I think everybody enjoyed the technology with its new approach.*

- *When the learners had to build their biogas maker – I had to stop the parents from doing it. One farther wanted to build a real big thing for his daughter's group.*

This particular pre-service teacher makes the following comment, which highlights one reason why her learners and their parents had positive attitudes towards PBL. It is embedded in her personal teaching philosophy:

- *I gave them a lot of motivation, and I believe if you show your enthusiasm they get it from you.*

Sub-code 4.2: Problems experienced by learners and pre-service teachers

Initially the problems experienced by learners and pre-service teachers were coded as two separate categories. After applying the reasoning principle of intuiting, it was realised that some of the problems experienced by learners are actually related, or can be traced back to the problems which the pre-service teachers have experienced. See Section 5.2.5 where the empirical results are presented together with comments made by the learners themselves.

Some of the learners could not understand why they were being treated differently from the other class, which was the control group. They requested the following from the pre-service teacher:

Pre-service teacher A: *They also wanted the notes which the other class received, but "B" explained it nicely to them.*

Interviewer: *Mmm?*

Pre-service teacher B: *Yes, I told them that we didn't want to teach them facts only, but also the process of working through the facts to be able to do something useful with the facts. They understood this idea quite well. I must say that I am glad that we were two students.*

Interviewer: *Why?*

Pre-service teacher B: *I think if a facilitator doesn't know what he is doing it can be chaos in a big class.*

Interviewer: *Why do you say that?*

Pre-service teacher B: *There is a lot of noise and the more exited they become, the louder they speak. They also move around a lot.*

The next section of the interview with pre-service teacher A and B illustrates the nature of the problems experienced simultaneously by learners as well as the pre-service teachers. It can be speculated that some learners tend to loose interest towards the end, due to the lack of experience on the part of the pre-service teachers in group facilitation skills. The following quotation suggests that these particular pre-service teachers had a narrow view of how to teach the OBE-PBL way:

Pre-service teacher A: *Some of the groups were fine, but I was really worried about some of the groups. It seemed that they loose interest if they* *really don't see their way out. Although we encouraged them not to loose heart. I know that I am a facilitator who is not supposed to transfer, but sometimes I felt like doing it.*

Pre-service teacher B: *I agree with "A". I think we still need a lot of experience in working with co-operative groups. The easy way out will be just to tell them what they need so that they could progress.*

In another section of the interview pre-service teacher A made the following comment about her role and function as facilitator of learning:

- *... but you can't just leave them, some won't investigate anything if you just leave them.*

She also suggested a possible solution to the problem that some learners were not committed to work:

- *It will help if you know the learners and then put them into a group which will pull them along.*

Another pre-service teacher described her actions during the act of facilitating learning. When describing her practice experience, she also mentions moments of frustration experienced by learners. After she explained what she did in the control class she continued explaining how she facilitated the experimental group. This explanation also shows a narrow view of how to facilitate learning according to the OBE-PBL way:

- *In the other class I moved in between the different groups all the time. Actually all I did was to encourage and motivate them. Although they asked me questions when I reached a group, I didn't really give them any hints, because the idea is that they do the work, isn't it? Sometimes I got the idea that some individuals were very frustrated with this method.*

Another pre-service teacher also communicated a need or problem experienced when she said *"it was difficult for me to determine how much feedback to give them".* She remarked as the follows:

- ***Pre-service teacher**: It took a lot of my energy to work in this way. All the learners wanted your attention at the same time. If a co-operative group shows you their progress it was difficult for me to determine how much feedback to give them.*
- ***Interviewer:** What feedabck did you give them?*
- ***Pre-service teacher:**My feedback was of the nature: 'That's OK', 'It's great' , 'You need to rethink this', 'You need to add something' and so on.*

In one of the log-books a pre-service teacher wrote the following:

Day 1:

The problem was presented to the learners.

- *Each learner had the opportunity to experience it individually.*
- *They then asked if they could work in groups – a question which we anticipated. They were divided into co-operative groups as suggested by their regular teacher.*
- *Instead of brainstorming and discussing it with their group members, I was showered with questions. I didn't really know whether I was supposed to answer all or some of these questions. I think some of the learners were just chancers who were too lazy to tackle the problem and wanted me to give them shortcuts, I think. I might be wrong.*

In the final conclusion on these results more will be said about the training needs of pre-service teachers in their new role as facilitators of learning in an OBE-PBL learning environment, which came to the fore in this interview.

Sub-code 4.3: The learners' experience of co-operative learning

In the initial design of the experimental group intervention, it was decided not to divide learners into groups straight away. Only after each of the learners had a thorough personal experience and a basic understanding of the problem, it was anticipated that they would request to work together, from where they would be divided into groups. The rationale behind this decision was to give learners ownership of their request, which would contribute towards commitment towards the group and the project.

For some learners, as was already reported, one of attractions of the project seems to be the fact that they could work together. Usually learners only work together on an ad hoc basis when they do practical work, but not in an organised way according to criteria which are valid for co-operative learning. (See Section 3.4.3 for criteria to design co-operative work.) One pre-service teacher explains how she facilitated co-operative learning:

- *Normally they work in groups when they do practical work only – but then they don't divide the work up so that each is responsible for something. To make sure that each learner experienced the whole process, I reminded them frequently to use their checklists. They seemed to forget that.*

Another pre-service teacher also explains how she accommodated the principle of individual accountability in co-operative learning when she facilitated learning:

Pre-service teacher C: *Two of the groups have done good research on the problem. They have divided the research amongst themselves and each member had to report back to the group on their part of the research.*

Interviewer: *Did they themselves decide to divide the research work between one another?*

Pre-service teacher C: *No, I told them ... Facilitated rather ... to do that, because I wanted them to work co-operatively.*

In her log-book, one pre-service teacher reported that one of the all-boys groups, also referred to in Section 5.3.3 Sub-code 4.1, socialised too much and did not take up their responsibility to co-operate to solve the problem. This was an all-boys schools, thus all the groups consisted of boys only. Her other groups however, were progressing at a satisfactory rate. She writes the following:

> *"Week 3: I told the one group that they had to pull up their socks, because they still had a lot of work ahead. I asked them several times now to pay more attention to their work. Maybe I should have broken this group up and placed them with a well functioning group. The other groups pulled their weight. Sometimes they had conflict, especially when it came to the making of the energy device. Those were good, healthy arguments".*

Sub-code 4.4: Quality of learning

To fully report on the quality of learning which occurred as a result of the PBL strategy, the quantitative data also need to be considered. This will be done in detail when the findings are discussed in the last chapter.

In the interview one pre-service teacher concluded that "we *didn't realise that it was such hard work to do our own research and to plan the whole thing on our own"*. This response by a pre-service teacher correlates with the empirical data and comments made by learners from the experimental group. In Section 5.2.5, 79% of the learners indicated that they had to work very hard to execute the PBL task. In the qualitative comments, learners requested more time to engage in the PBL task. Another pre-service teacher said that she even had to consult professors in the Department of Biochemistry to discuss information she needed to solve the problem. These results are indicators of the pre-service teachers' and learners' active involvement in the problem-solving process, which is a premise for effective knowledge construction. The post-test results also showed that PBL learners performed significantly better in some questions which were formulated on the higher cognitive levels according to Bloom's taxonomy (See Section 5.2.2). Another pre-service teacher mentioned that "*some of the learners said that they have really learnt something and that it was fun"*.

In the last two days the final solutions to the technological problem had to be presented to a delegation from the Department of Minerals and Energy, as was promised in the initial problem statement. Of all 26 groups only one group did not do a final presentation. One pre-service teacher wrote in her log-book that she was very satisfied with the presentations.

- *I decided to invite their real teacher to attend their presentations. She could at least see that I did not waste her kids' time.*

- *Lynette's (fake name) group made the best presentation. They made a TV programme to introduce their product to the world. Different interviews were conducted with the research team to highlight the advantages* and disadvantages of their design.

Another pre-service teacher wrote in brackets in her log-book that *"the gas burner was better than some of our solutions "*. It should be remembered that the pre-service teachers and the grade 10 learners were exposed to exactly the same problem.

The same pre-service teacher who consulted the Department of Biochemistry, mentions that her creative thinking abilities were challenged by PBL. It must be kept in mind that this pre-service teacher, like the others, had already completed her pre-graduate Baccalareus in Sciences degree. As previously indicated she explains the following:

- *At the beginning of the year I could not think creatively at all because it was never necessary to be creative. Your approach has challenged me to develop my creative thinking to such an extent that I can think diverse about problems and solutions.*

Finally, the PBL experiences have impacted more than her learning only, but her person as well. She says that *"I have personally grown and I believe so have my fellow students"*.

Results on Code 5: Pre-service teachers' perceptions of outcomes-based education after the PBL training and practice experience

Table 5.13: Code 5: Pre-service teachers' perceptions of outcomes-based education after the PBL training and practice experience.

Code 5:	**Pre-service teachers' perceptions of outcomes-based education after the PBL training and practice experience.**
Interview question: Technology education was implemented within an OBE framework. What impressions of OBE have you gained through this training and practice experience?	
Code 5.1:	OBE as problem-based methodology, drawing on research, using a variety of resources
Code 5.2:	The difference between OBE and the transmission model (traditional teaching)
Code 5.3:	Outcomes are more than textbook content

In this interview question, the pre-service teachers seem to focus their perceptions of OBE on teaching strategies as they manifest in classroom practice, and not on the principles, philosophy and systems associated with OBE.

Sub-code 5.1: OBE as problem-based methodology, drawing on research, using a variety of resources

Four of the six pre-service teachers felt that technology education can be taught effectively through a PBL model. One of them said that PBL is a good example of what OBE strategies can look like when implemented in practice. The comments which follow, emphasise elements of the learner-centred approach associated with OBE. It also indicates that pre-service teachers realise that technology has a problem-based nature and will therefore be taught more effectively through strategies which enhances active learner involvement and problem-solving. The pre-service teachers made the following remarks in this regard:

Pre-service teacher C: *I don't think technology education can be taught in a different way than the method which you have used.*

Interviewer: *Explain more.*

Pre-service teacher C: *Finding solutions to problems, is something that cannot be given – the individual has to look for it by doing thorough research. Doing your own research under the guidance of a facilitator is OBE methodology, isn't it?*

Pre-service teacher E: *I don't' think you can teach technology in another way, than this way. If you give them problems and research to do, that is OBE. OBE is about taking them out of the classroom away from one textbook to the real life outside – like I did with the coal mine fieldtrip.*

Pre-service teacher D: *I think this training in technology education has given me a good idea of how to teach in an OBE way.*

Interviewer: *What ideas did you get?*

Pre-service teacher D: *How to prepare and design problems which may help learners to demonstrate a specific outcome in technology.*

Pre-service teacher E: *How to look for resources for a resource kit and how to plan co-operative group work.*

- **Pre-service teacher F:** How to plan integrated learning tasks.

- **Pre-service teacher B:** Doing your own research under the guidance of a facilitator is OBE methodology, isn't it?

Although pre-service teachers touched on issues related to OBE, especially classroom practice, they seem to have a narrow view of OBE in terms of the place of direct instruction in OBE. They seem to think that direct instruction has no place in OBE. Maybe the interview question should have been rephrased to communicate the idea that they should give their understandings of OBE in its broadest sense. The pre-service teachers communicated their understanding of OBE within the narrow context of technology education only, which might be expected because that is what they experienced.

Sub-code 5.2: The difference between OBE and the transmission model (traditional teaching)

One of the pre-service teachers actually contrasts the active learner participation with the passive, receptive role of the learners in the traditional class. The principle of challenge is also contrasted with the idea of imitating and executing experiments in a recipe like fashion.

- *Well, in technology education, like in science education, learners preferably have to discover and explore on their own. In technology education they have to design and make their own ideas –they are not given a design to just copy and make. It seems to me that is what OBE is all about in practice.*

- *These learners had to analyse their own information from the kit and other books and the internet. The other class received notes and lessons with all the information. They were given the experiments and exactly how to do it. They actually only had to follow the prescribed instructions. That's the difference between OBE and the other method.*

Three of the pre-service teachers mentioned the idea that OBE implies a new role for teachers towards becoming facilitators of learning, which goes beyond transmitting knowledge.

- *I know that I am a facilitator who is not supposed to transfer, sometimes I felt like doing it.*

In the final chapter when all the results are integrated, more will be said about how learners acted out their role as facilitators in the classroom context. At this stage, it seems that this is one of the areas in which pre-service teachers had a narrow view which needs to be broadened in a future training programme.

Sub-code 5.3: Outcomes are more than textbook content

The pre-service teachers referred to as A and B, often referred to the concept of processes and skills as some of the outcomes for technology education. The interview with the two pre-service teachers acknowledges the fact that they view outcomes to be more than memorising and recalling the textbook information:

Pre-service teacher A: *I think that I understand now that outcomes are more than facts and textbook content. In technology one of the outcomes is the problem-solving process which learners need everyday in their lives. Outcomes can also be the skills which B has referred to in his explanation of technology.*

Pre-service teacher B: *And I think we showed the science teachers in this school a good example of OBE methods.*

Interviewer: *What are the OBE methods?*

Pre-service teacher B: *No lessons, where teachers transfer information, but problems and co-operative work where learners look for their own info.*

This last comment by "B" also confirms a narrow view of OBE teaching strategies. It seems that the idea of direct instruction, when necessary, has no place in this teachers' repertoire of teaching strategies.

5.3.4 General conclusion: Qualitative results

The pre- and post-training results elicited the pre-service teachers' perceptions and experiences on technology education, PBL, OBE and the inter-relationship between them. These results obtained from the pre-service teachers, will be correlated with the quantitative and qualitative results obtained from the learners. All the results will be merged and reflected upon to get a holistic picture of the research and its main findings.

5.4 Summary

The first section of this chapter presented the quantitative data obtained through empirical methods from the learners. The results of the pre-, post- and attitude questionnaire were presented and briefly discussed. Comments made by learners from the experimental group were selected as a means of gaining some level of insight into the reasons behind certain empirical results. The second section of the chapter focused on the qualitative results from the pre-service teachers. Their pre- and post-training and practice understandings and experiences were analysed, coded and presented in a narrative format.

The last chapter will discuss the collective results emanating from this research in detail. The research questions will be revisited to determine to what extent they have been answered. The final step will be to make recommendations for future interventions and research in this field.

CHAPTER 6

DISCUSSION OF RESULTS, REFINEMENT OF THE OBE-PBL MODEL AND RECOMMENDATIONS FOR FUTURE RESEARCH

6.1 Introduction

Where the previous chapters focused on the design and the two layered implementation of the OBE-PBL model, this chapter will discuss and reflect on the major research results. This will be followed by suggestions for the refinement of the model and the implementation thereof in the training of pre-service teachers. The chapter will conclude with recommendations for continued research in the field of PBL as a strategy to operationalise OBE and for facilitating learning in technology education.

6.2 Discussion of results

Research results were obtained from two levels. On the first level, the pre-service teachers were trained for an outcomes-based technology curriculum and problem-solving through PBL. On the second level, the PBL trained teachers had to demonstrate their OBE-PBL competencies in technology education, in real classrooms. The results generated on the second level had to answer the research question on whether the OBE-PBL model was internalised to such an extent that the pre-service teachers could **transfer** their competencies from university classrooms to real classrooms – their future workplace.

These results were presented in Chapter 5 and will now be discussed from a holistic perspective. Results obtained from the learners at the real classroom level will be discussed first, followed by the results obtained from the pre-service training level.

(i) The quality of knowledge acquisition and construction by learners

In PBL, one of the most frequently mentioned barriers to implementing PBL curricula is the pressure for content-coverage, which sparks the debate about the breath or depth of content. See Section 3.3.7 for an elaborated discussion on this debate. Central to the debate is the assumption that learners will learn less information if they are exposed to a problem-based learning environment (Gallagher & Stephien, 1996:259-260). Although research conditions may be different from previous PBL studies, this research may contribute in the following way to the body of knowledge in the depth versus breadth debate.

The questions on the pre-test and post-test were each classified in terms of the cognitive levels of Bloom's taxonomy in order to determine whether the experimental treatment may have been more effective for low/high levels of cognitive learning. The results were mixed and the post-test averages of the experimental and control groups did not differ significantly. However, the control group learners who were taught through direct instruction, scored significantly higher than the experimental group in two questions, categorised as low cognitive questions. On the other hand, the experimental group learners who were taught through PBL, scored significantly higher than the control group on one low and two high cognitive questions. Furthermore, the statistical comparison between the post-tests of the experimental and control groups were not the only comparisons which were conducted. Comparisons between the pre-test and post-test averages of each of the groups were also conducted. The finding was that the experimental group increased their achievement in terms of knowledge and skills acquisition and construction from the pre- to the post-test significantly. This was not the case with the traditional, didactically treated group.

This implies that the OBE-PBL model used in this research did not foster lower levels of knowledge acquisition, as was the finding in Section 3.3.7. In the investigation discussed in Section 3.3.7, PBL interventions with medical interns showed that they scored above average on four clinical subjects which involve several higher order thinking, reasoning and problem-solving skills, but below average in knowledge of anatomy. The finding in this research is congruent with the finding obtained with the medical interns who scored higher in subjects that demand higher order thinking. The PBL design, as is was used in this research, also promoted higher order cognitive performance during knowledge construction in selected questions. The reasons why PBL has the potential to promote higher order thinking are embedded in its very nature and was discussed extensively in all the sub-sections of Section 3.3.4.

The finding of this research, however, differs from the findings with the same medical interns referred to in the previous paragraph in the following regard. The medical interns who were taught through PBL scored lower on average on their knowledge of anatomy compared to their counterparts who were taught through lectures. In this research, although the PBL learners scored significantly higher than their lecture taught counterparts in the higher order questions, the two groups did not differ significantly on the total test averages. The PBL learners even scored better than their control group counterparts in one low cognitive question. This finding merely shows that PBL does not necessarily "harm" knowledge acquisition and retention of content facts. This finding supports the results obtained from an investigation with high schools learners in the subject American History (Section 3.3.7) who wrote a standardised multiple-choice test after a PBL and traditional teaching intervention for one year. Their finding accepted an alternative hypothesis that stated that PBL does not result in lower levels of fact acquisition.

The findings of this particular PBL research can be summarised as (a) PBL promotes higher order cognitive thinking and knowledge construction and (b) PBL does not harm and result in lower levels of fact acquisition. A possible reason for the relationship between lower and higher cognitive performance can be traced in the following explanation. One of the existing research studies in this line, the Harvard Social Studies Project, obtained results supporting higher order thinking as an avenue to factual learning (Olivier & Shaver, 1963). The fact that factual acquisition and retention are not inhibited by PBL is not surprising. A problem creates a meaningful context for learning in which relevancy is maximised and content overload minimised (Maatsch & Huang, 1986:70).

Finally, these results also provide information about how the pre-service teachers facilitated learning in the real classrooms in terms of knowledge acquisition and construction by the learners with whom they intervened. The fact that one of the aims envisaged with PBL, which is to provide a counter act for rote learning and to enhance higher order thinking skills, was realised in some of the higher order questions in the post knowledge test, is significant. It shows that this group of pre-service teachers were capable of transferring competencies associated with implementing PBL, from their University classroom to real classrooms.

(ii) Learner attitudes towards the OBE-PBL experience in general

Learners generally held positive attitudes towards their OBE-PBL experience. The majority of 65% indicated that they really learnt something valuable from the PBL task, and 76% enjoyed the "*new method of teaching*". The Fishers' Exact Two Tail Test indicated that it was particularly the above average achievers who significantly enjoyed and learned about problem-solving through PBL as facilitated by the pre-service teachers. A possible reason for this result might be traced back to the fact that above average achievers "*exhibit high independence in learning and are better off in low-structured situations in which they can exercise their own initiative*" (Ornstein & Hunkins, 1993:8). Also see Section 2.2.3 where characteristics of a humanistic, learner-centred curriculum are discussed. The low achieving learners often lack "*the inner controls necessary for self-discipline and the cognitive skills necessary for independent learning*" "(Ornstein & Hunkins, 1993:8). These learners need and are more comfortable in highly structured environments and activities. Berliner (1982) and Ross & Kyle (1987) proclaim that direct instruction is one of the most effective strategies to teach explicit concepts and skills to low-achieving learners, and in the present study, several low achievers actually expressed their preference for direct instruction over PBL. Of all the below average learners, 18 of the 34 below average achievers did not enjoy PBL, but 26 said that they indeed did learn something valuable from the PBL task, while 19 of them said that PBL has helped them to learn how to solve problems.

The learner comments (Section 5.2.6) however, included below as well as above average learners who wanted notes and requested that teachers work through it with them. On the other hand, there were below average achievers who made it clear that they enjoy working on their own and that it was empowering not to be treated like a "*zombie*". (See the result in Section 5.2.6). **The fact that above average achievers significantly enjoyed and**

learned how to solve problems through PBL, does not mean that lower achievers should not be challenged and empowered to develop the necessary skills for functioning responsibly and independently in an ill-structured learning environment. On the contrary, life outside the classroom is complex, not highly structured, and sometimes threatening, whether learners prefer it or not. Real life demands will not highlight the essence of a problem and provide the recipes to be used in the solving of a problem. Teachers, mentors or even systems will not always be there to provide direct instruction, the next steps or a structured, safe environment, even though learners (including children and adults) might prefer it to be that way. The purpose of transformational OBE and the South African critical outcomes, are to prepare learners to perform complex real life roles and to make them life-long learners. On the other hand, one OBE principle contends that successful learning leads to more successful learning and that all learners should be successful. This has the implication that learning environments, including PBL environments, should be flexible enough to create conditions for every learner, whether they are above or below average achievers, to be successful in learning. Pre-service teacher education programmes need to take cognisance of this fact. When the refinement of the OBE-PBL training model is discussed, a recommendation will be made on how pre-service teachers may be trained to facilitate the complexity of working with learners with diverse abilities and learning style preferences.

There were also indications that the high levels of enjoyment which PBL learners have experienced, resulted in heightened levels of intrinsic and extrinsic motivation. One learner commented that it was "*nice to do something different from the normal*". The normal refers to the direct instruction strategies which dominated their learning environment during their previous 10 years of schooling. Other learners seemed to be motivated by the hands-on nature which puts "*science in a new, different light*". Learners also would not have involved the parents the way they did if they were not motivated by the task. (See the pre-service teacher's comment in Section 5.3.4). A below average achiever was intrinsically motivated by the fact that he perceived that he was not treated like a "*zombie*" in the PBL environment. If the PBL learners were not inspired and motivated by their PBL experiences, they would not have asked for more time to successfully complete their PBL task. Unmotivated learners would not have spent a great amount of their own time to search for resources way beyond the resource kit. Both above and below average learners indicated that more time on task would have come in handy. 79 % of the learners indicated that they really had to work hard to execute the PBL task. Learners would not have been willing to put much extra effort into work which was not part of the regular curriculum and which did not contribute towards a test and exam mark, if they did not derive some form of instrinsic motivation, self-worth and pride in what they were doing.

The design portfolios and presentation of the final technological solutions were proof of their motivation and showed that some learners accessed resources way beyond the resource kit. They searched and included information from the local school and community library, as well as from the world of electronic media. This finding is in line with the findings discussed in Section 3.3.6. where medical learners who have been exposed to PBL in the first two years of their studies, had significantly more positive attitudes than conventional curriculum learners towards the curriculum. The PBL medical learners described the curriculum as stimulating and enjoyable and indicated that it excited their curiosity and even that of faculty members.

This validates the fact that the pre-service teachers facilitated the PBL tasks in accordance with their nature, which is to engage learners in high levels of intellectual and hands-on activity, responsibility and accountability. It should also be mentioned that the pre-service teachers' own motivation and enthusiasm could also have effected the learners' attitudes. All the pre-service teachers who facilitated the PBL task volunteered to do so, therefore it can be assumed that they were generally not negative towards PBL. The one pre-service teacher in particular had a very dynamic and enthusiastic approach to teaching in general and believed in the potential of PBL as a learner-centred strategy.

Valuable results were generated on the learners' experience with co-operative learning in which they had to engage as part of the PBL task. While the majority of 74% indicated that it was valuable to work co-operatively, only 49 % preferred to work co-operatively and 34% preferred to work individually. The majority of groups were functioning effectively, while three of the twenty six groups did not. One group in particular was not composed with the assistance of the regular classroom teacher, but learners could decide for themselves with whom they wanted to work. This group's social interaction dominated the learning processes. It was the only group who did not present their final solution. Where the regular classroom teachers, who had a longstanding relationship with the learners, assisted with the selection of co-operative team members, learners with complementary skills were grouped together. These groups functioned well and found co-operative work profitable.

One below average achiever explained why he was frustrated with the group he was in when he said that "*learners who were supposed to gather particular information did not bring it to all group members*". Another learner who scored 30% in the post-test felt that he wasted time with senseless group debates. The fact that group debates took place, is a positive indication of the fact that learners were sometimes at loggerheads with one another which is the trigger for meta-cognitive reasoning and which is an important process to help learners make sense of their learning. This particular learner is not aware of the cognitive and meta-cognitive processes involved in group interaction. In future training programmes, pre-service teachers should be trained how to manage disfunctional co-operative groups. In practice however, when teachers have a longstanding relationship with learners and know each learner in the classroom, the teacher will be able to compose a well functioning, heterogeneous group with complementary skills. In the schools where the regular teacher advised the pre-service teacher on which learners could be grouped together, there were no major problems in the functioning of those groups.

In other groups, healthy cognitive conflict stimulated the reflective thinking abilities of learners. Learners were required to explain their contribution, elaborate and defend their position to the others. One learner encapsulated the value and theory of co-operative learning when she said that "*it was interesting to hear how my friends think*". This might be a reason why 47% of the learners used the research (meta-learning) checklist "quite a lot" and only 34% used it "very much". It was anticipated that learners would use the meta-learning checklist more often than they did. The research checklist was included as a meta-learning checklist, to stimulate reflective thinking. It seems that the co-operative groups fulfilled the role of a reflective instrument, such as the meta-learning checklist to learners.

Although general attitudes towards PBL and its related strategy (co-operative learning) and instruments (research checklist, and resource kit) were positive, there were learners who displayed negative attitudes. Reasons may be traced from the itemised attitude questionnaire to an extent, but mainly from the learner comments and also from the pre-service teachers' feedback, which will be the focus after this discussion. Some results show that learners were not used to, and thus comfortable with being purposefully pushed out of their learning comfort zones which tipifies the normal resistance to change phenomena. It should be realised that some learners might not necessarily be negative towards PBL and co-operative learning, as such. Some learners find the approach very different from what they became used to, especially in science classes during their previous 10 years at school. For some, the challenge of really taking responsibility for their own learning and that of the co-operative group members, was threatening. This trepidation towards self-directed learning takes time to overcome. Schmidt, Henny, Boshuizen & De Vries (1992:195) found in a study with first-year university learners that "*they seem to need at least 6 months to adapt to this new learning environment in which they are responsible for what they study and how they study*".

It seems that pre-service teachers and any practitioner who whishes to introduce change in some way or another, should take cognisance of the fact that learners also need to practice new strategies such as co-operative learning in PBL before it can render maximum benefits to meaningful learning. In the light of the above mentioned quotation, it seemed that the pre-service teachers had quite an impact to achieve the post-test results and influence the attitudes of learners the way they did in a one month period.

(iii) Perceptions and experiences of pre-service teachers towards their OBE-PBL training and practice experience in general

Generally, the PBL training and practice experiences were described as different but valuable. This claim is validated by comments such as "*I liked it very much. ...This was the one subject in which I have learnt the most in the whole year*". PBL is used as a curriculum design process with the purpose of making learning more real and relevant for learners. One pre-service teacher who rates the course successful says that "*the training was very practically orientated and relevant and it is this fact which made the course successful*". This finding is coherent with the findings of Tanner, Galis & Pajak (1997:10) who also used PBL in a course on the Advanced Preparation of Educational Leaders. Students in their PBL course rated the value of the PBL course significantly higher than the traditional course. Also see the detailed discussion on this issue in Section 3.3.6. The PBL experience has even impacted one pre-service teacher beyond the academic domain. She says that "*I have personally grown and I believe so have my fellow students*".

The following paragraphs will highlight the salient findings from the pre-service teachers, obtained from the pre- and post-training instruments. The instruments mainly probed the pre-service teachers' perceptions and experiences of technology education, PBL, OBE and the inter-relationship between them. The initial perception held by pre-service teachers was that technology education should primarily prepare learners for the high-tech electronic world in which they will function and that this Learning Area might as well also be called "applied science". This perception broadened in scope and depth after the interventions to include the concepts of problem-based, process-driven and creative challenge. This proves that pre-service teachers understand an important characteristic of the nature of technology education as it is conceptualised in South African education. In other words, they express the fact that process in technology education is as important as product and that process is both a means and an end. The typical comments can be read in Section5.3.3 which validate this claim.

The learner results indicate that the pre-service teachers were reasonably successful in their first attempt to transfer OBE-PBL competencies to their future workplace – the classroom. It also seems that the training programme has impacted on the pre-service teachers' conceptualisation of OBE (See the comments in Section 5.3.3), but some had a narrow view of OBE. This manifested in the practice where they had to facilitate learning. Two of the pre-service teachers were sometimes uncertain as to **how to act out their new role as facilitator of learning,** especially when particular learners really experience confusion and anxiety beyond constructive measures. The following quotation by a pre-service teacher illustrates the narrow perception of the role of a facilitator of learning:

> *Some of the groups were fine, but I was really worried about other groups. It seemed that they loose interest if they really don't see their way out. Although I encouraged them, they seemed to loose heart. I know that I am a facilitator who is not supposed to transfer answers to them, but sometimes I felt like doing it.*

One below average achiever (40%) in this particular pre-service teacher's class reflects from a learner perspective a need for more direct assistance, which the pre-service teacher also sensed. The below average learner mentioned that the "*project was a little bit confusing. Information was handed out and then learners had to report on the information and hand a solution in*".

Pre-service teachers seemed to know that they are facilitators of learning in an OBE-PBL learning environment, but two of them lacked the practical know-how of how to deal with learners who really had a break down in the learning process and who could not proceed constructively. Two of the pre-service teachers had the limited perception that once they have designed and planned the OBE-PBL task and resource-kit, that their role as facilitator includes many functions such as reflective questioning, motivating learners and supporting them emotionally. What these two teachers were uncertain about was the role of direct teaching and information transmission in their new roles as facilitators of learning when particular learners really became static in their learning progress. It almost seems as if two pre-service teachers had the perception that facilitating learning, is to adopt a laissez-faire position in the learning environment. Considering the work of advocates for "free" education, this perception held by pre-service teachers might not be too narrow at all. According to Biehler (1974) these advocates suggest that learners should learn almost everything on their own or by interacting with their peers. Apparently "*any attempt on the part of the older, more knowledgable adult to explain something he has learned is considered a hinderance rather than an aid*" (Biehler, 1974:122). Some self-directed learners will thrive in their learning and creativity when they are only encouraged and supported emotionally, but learners who are really confused and stressed need to be directed intentionally, without necessarily switching back to a spoonfeed mode. The facilitator is responsible not only to initiate the learning, but to "*ensure the maintenance of learning within the framework of the problemsetting*" (Slabbert, 1996:93).

This is a very delicate diagnosis that pre-service teachers, or rather all teachers, will have to make, before adopting a particular teaching strategy in OBE. The danger exists that a pre-service teacher may easily slip back into the modes of direct instruction if he or she cannot diagnose whether and where a learner is really experiencing a break down in the learning process. The danger exists that if a facilitator intervenes too soon, the learner has been deprived of an opportunity to search his internal and external resources which could have placed the learner on a higher level of intellectual empowerment. As already mentioned, one of the OBE principles contends that all learners should be successful – they should maximise their potential. It is the core business of the teacher to create conditions and expanded opportunities for all learners to be successful. By intervening too soon by means of direct instruction, or not at all, a teacher does not create the conditions to maximise a learner's potential.

In the act of facilitating learning, the pre-service teachers should know how to create and maintain **creative tension** in groups and in individual learners who cannot manage it consciously or sub-consciously themselves. The learners who have internalised meta-learning skills will most likely be able to reflect on their own learning processes and consequently make the best decisions to maximise their learning. See Section 3.3.5.3. for a discussion on which conditions and teaching strategies induce meta-learning. The creative tension maintained by the facilitator of learning is not anxiety – that is psychological tension (Senge, 1990:357). Creating and maintaining creative tension implies that the gap between the **vision of solving the problem** and the actual **reality** in a particular stage in the process of solving the problem, should skillfully be managed by the facilitator. If a facilitator of learning allows this gap to grow too big, learners may become anxious, lose interest, become unmotivated and even disempowered in their learning. Skillful management of the gap will challenge and energize learners to maintain their learning towards the solution of the problem. Teachers need to be extremely flexible and adaptable in their facilitation skills. They need to make moment-to-moment decisions depending on the situation when a strategy such as PBL is used which is open-ended, ill-structured and guided by learner activities and which is therefore unpredictable. The PBL environment differs from the direct dominant teacher-centred environment where the teacher controls the activities and which is therefore a predictable situation. In the less predictable learner-centred environment created by PBL, learning facilitators have to "think on their feet" to make the best moment-to-moment decisions in an attempt to optimise the learning potential of a learner or group of learners.

This result implies that a pre-service training programme needs to focus intentionally and expand on problems which will develop competencies in the practical act of facilitating learning in complex classrooms where learners have a variety of abilities, learning styles, levels of prior knowledge, self-esteem and cultures. In the OBE-PBL training programme the pre-service teachers practiced on their peers when it came to the execution of a designed PBL technology learning task. Their peers are adult learners and far from the real classroom situation with 25 and more senior secondary learners per class. Although these particular competencies will develop and grow with more real experience once pre-service teachers start their careers, it needs to be addressed prior to the authentic practice during the OBE-PBL training. On the other hand it can be argued that no training programme can prepare teachers to transfer their competencies one hundred percent to the real work place. There are competencies that no curriculum or training can develop, but only the experiences with the real situation itself.

These results serve as sign posts as to where the strengths and weaknesses of a pre-service training programme, implementing the PBL strategy for the training of an OBE technology curriculum, lies and which could not have been anticipated during the design phases of the OBE-PBL model.

6.3 Reflections on the critical research questions

At this final stage of the research it is valuable to recall the critical research questions which attempted to answer the overarching problem. The previous section where the most prominent results were highlighted and discussed, has actually already provided answers to the research questions. This section will summarise and highlight the answers to the questions.

How should teachers be trained to become effective facilitators of learning in an outcomes-based technology curriculum?

The broad problem formulation was broken down into research questions, which provided foci for the research. The specific questions which were addressed in this research, were the following:

1. What is the nature, extent and vision of educational transformation in South Africa?

2. What is the conceptual framework and implications of the outcomes-based education paradigm for the professional training and development of teachers?

3. What is the substantive and syntactical structure of technology education?

4. Is a problem-based learning model (PBL) a suitable, effective model to use in the training of pre-service technology teachers who have to facilitate learning within an OBE framework?

5. Will pre-service technology teachers be able to transfer their competencies obtained through a PBL training model to authentic classrooms to facilitate learning through PBL?

6. How will the PBL strategy used by the pre-service technology teachers impact on the learning quality and attitudes of learners?

Answers to the first three questions imply theoretical underpinning. These questions were explored and substantiated in Chapters 2 and 3. The insights gained through the literature research culminated in the construction of a model in Chapter 3, which was labelled the OBE-PBL model. This model proposes the following:

- A **meta-structure** for organising the entire curriculum for technology educator training, consisting of outcomes and enabling content, around problems.

- A **strategy** to be used for training of the pre-service teachers who have to facilitate learning in technology education from an outcomes-based perspective.

The author embraces the principle of training teachers the way they are expected to teach in real classrooms, also referred to as modelling. After designing the model, it had to be implemented and evaluated in practice on two levels – the university classroom and the real school classroom level. The strategy which was used to implement the OBE-PBL model on the two levels, was the PBL strategy.

The last three questions will be addressed now. The answer to question 4 will ultimately provide the answer to the overarching research question. Question 4, however, draws on the evidence and answers provided by questions 5 and 6. Therefore will the final answer to question 4 be revisited after questions 5 and 6 have been answered.

Question 4: Is a problem-based learning model (PBL) a suitable, effective model to use in the training of pre-service technology teachers who have to facilitate learning within an OBE framework?

The PBL model referred to in the question which was designed to operationalise OBE in technology education, was called the OBE-PBL model. The OBE-PBL model proved to be of some value to the pre-service teachers during their training and the implementation of their competencies in authentic classrooms. It provided them with a theoretical and practical mechanism of learning about technology and problem-solving through problem-solving. The following comments made by different pre-service teachers contribute to the claim that the OBE-PBL model is a suitable model to use in the training of pre-service technology teachers who have to transfer their competencies to real classrooms where they have to facilitate learning within an OBE framework. The first comments encapsulate the pre-service teachers' experiences with PBL during their training:

- *I liked it very much. ...This was the one subject in which I have learnt the most in the whole year.*
- *I have personally grown and I believe so have my fellow students.*
- *The training was very practically orientated and relevant and it is this fact which made the course successful.*
- *It was really different to what we were used to. All I know is that we were given many problems, some shorter and some longer ones which finally helped us to understand tech education.*

- *Your approach has challenged me to develop my creative thinking to such an extent that I can think diverse about problems and solutions.*

The following comments summarise the pre-service teachers' experiences with PBL during their authentic teaching experience:

- *I don't think that you can teach technology in another way than this way. I will definitely use it to teach other subjects as well next year.*
- *Finally I think that this approach will not only work for technology, but for many other subjects as well.*
- *Personally I think that the learners in this school have gained much from this whole project.....I think everybody enjoyed technology with its new approach.*
- *Some of the learners said that they have really learnt something and that it was fun.*

Generally, the OBE-PBL model gave the pre-service teachers an understanding of the philosophy and especially the classroom practice associated with OBE within the context of technology education, as can be seen throughout all the code-categories which emanated in the analysis of the interviews with the pre-service teachers. It seems that the OBE-PBL model had particular value for training and classroom practice.

However, the OBE-PBL training model does not appear to have given the pre-service teachers a sufficiently strong theoretical understanding of OBE. It left at least two them with a misconception which is that direct instruction has NO place in OBE when facilitating learning. They seem to be under the impression that OBE-PBL prohibits direct instruction or learning assistance. It is also interesting to note that not even in the other subjects which they had in their entire Higher Education Diploma course and which are theoretically based and mainly presented through lectures, did they gain insights regarding the role of direct instruction in OBE. The pre-service teachers' timetable, Table 4.4 indicates all the subjects in which the pre-service teachers were enrolled. The subject, Didactical Pedagogics, which was run three periods per week, also addressed OBE. A possible reason for not recognising the role and place of direct instruction in OBE, might be explained as follows from the broader educational circumstances in South Africa. OBE was presented as an entire educational reform movement, which it indeed was and still is, to replace the traditional content-driven curricula and which was mainly delivered through direct information transmission methods. The intensity, flare and haste with which the new South African government introduced the OBE curriculum were overwhelming to the education fraternity. Many teachers, although not understanding or agreeing fully, perceived direct instruction as a taboo which had to be thrown out of the repertoire of teaching strategies, regardless of what would be best for a particular learner with a particular learning need. The whole education climate in South Africa at that stage was somewhat overreacting towards what was new that had to replace the old.

Generally the OBE-PBL training model has prepared the pre-service teachers to perform the following competencies described in the seven teacher roles in the Norms and Standards for Educators, some to a more and others to a lesser extent. Refer to Section 3. 2.2. for a detailed description of all the educator roles. This model has particularly impacted on the roles of learning mediator and interpreter and designer of learning programmes and materials. Only the most relevant competencies described in the Norms and Standards for Educators that were particularly addressed through the OBE-PBL model, will be presented here (Department of Education, 2000: 15-17):

- *Preparing thoroughly and thoughtfully for teaching by drawing on a variety of resources; the knowledge, skills and processes of relevant Learning Areas; learners' existing knowledge, skills and experience*: The OBE-PBL model intentionally developed the competencies related to planning, designing and preparation of a PBL learning environment. One pre-service teacher mentioned how she was challenged to "*think creatively*" when designing the problems for learners.
- *Using key teaching strategies such as higher level questioning, problem-based tasks and projects, and appropriate use of groupwork and individual self-study*: The OBE-PBL model intentionally prepared the pre-service teachers to facilitate learning in technology education, using the aforementioned strategies. The OBE-PBL model did not focus on the use of group work, but co-operative work during problem-solving. One pre-service *teacher mentions the following about the co-operative work that was part of their training*: "it makes a big task like this much easier". Another said that " *we brainstorm –*

the more ideas the better. We share the research work amongst ourselves, and we learn how to work with fellow students".

- *Creating a learning environment in which: critical and creative thinking is encouraged; learners develop strong internal discipline; conflict is handled through debate and argument and learners seek growth and achievement*: The OBE-PBL model intentionally prepared pre-service teachers to create and maintain a learning environment that stimulated critical and creative thinking. The nature of the problems the pre-service teachers learnt to design, had to stimulate critical and creative thinking. The debates that were sparked off in some of the co-operative groups, provided learners with the opportunities to learn how to handle conflict and arguments.

- *Using media and everyday resources appropriately in teaching*: The OBE-PBL model intentionally prepared pre-service teachers to design their own materials and to compile a resource kit to be used during the problem-solving process. One teacher mentioned that she landed up in the Department of Bio-Chemistry during her search for resources.

- *Understanding the pedagogic content knowledge – the concepts, methods and disciplinary rules – of the particular Learning Area being taught*: The pre- and post-training perceptions of pre-service teachers, presented in Sections 5.3.2 and Code 2 indicate an understanding of the nature, structure and rationale for technology education that has matured during the intervention.

- *Understanding the principles and practices of OBE, and the controversies surrounding it, including debates around competence and performance*: The training during the first months exposed pre-service teachers to the educational transformation processes in South Africa and the issues regarding OBE and its impact on teaching and learning.

The answer to question 4 will be enriched and refined once the following two questions have also been answered. In conclusion it seems that the OBE-PBL model is a suitable model to be used for the training of pre-service teachers who will have to teach technology education from an outcomes-based approach. It will however, need to be refined and improved to provide pre-service teachers with a more sound background in terms the role of direct instruction in OBE.

Question 5: Will pre-service technology teachers be able to transfer their competencies obtained through a PBL training model to authentic classrooms to facilitate learning through PBL.

A central concern of professional education and development and even other forms of training, is how to make certain that competencies acquired get transformed into ability to apply in the real work place (Everwijn, Bomers & Knubben, 1993:425). This teacher training programme attempted to teach the pre-service teachers in the same way they are expected to teach in real classrooms with the purpose of optimising the transferability of competencies during the pre-service school practice phase, but ultimately when they start their profession as teachers.

The previous answer pointed to the competencies which were developed through the OBE-PBL training programme. The feedback by pre-service teachers themselves and the learners with whom they worked, confirm that some of the competencies developed through the OBE-PBL training were transferred more effectively than others. The following competencies that the OBE-PBL intended to develop were not transferred effectively. This claim is justified by the fact that some pre-service teachers had a narrow view of OBE and consequently did not know how to address the need for direct instruction in their role as facilitator of learning in a PBL environment.

- *Adjusting teaching strategies to cater for different learning styles and preferences.*
- *Understanding the principles and practices of OBE, and the controversies surrounding it, including debates around competence and performance.*
- *Defending the choice of learning mediation undertaken and arguing why other learning mediation possibilities were rejected.*

This is the exact wording of the outcomes as described in the Norm and Standards for Educators' document. The researcher however, is adamant about the fact that pre-service teachers must not learn how to adjust their teaching strategies to cater for learner preferences only, because then most learners might prefer the strategies where they adopt a passive role and where a teacher provides all the structure, answers and notes. Within the context of PBL, which aims to develop autonomous, creative and problem-solving skills in learners, the pre-service teachers have to use the **real learning need** of a learner as a criterion to decide whether another teaching strategy such as direct instruction will be beneficial to the learner.

The lack of transferal of the above mentioned competencies is an indication of issues that need to be addressed in future implementation of the OBE-PBL training model. Section 6.4 will recommend a possible strategy of dealing with this problem. The following comment by a learner provides evidence that that particular pre-service teacher transferred the nature and structure of the problem-based technology learning task to the real classroom:

- *The project was interesting. It was something new. You do not have to learn everything like a parrot. It is nice to do things and practical work on your* <u>*own*</u>*. You get to work with something that you don't know at all and get to know it through your involvement.*

In summary, the OBE-PBL model did contribute towards the transferal of particular competencies which were cultivated during the OBE-PBL training. However, competencies related to understanding and implementing direct instruction within an OBE-PBL context, were not effectively transferred. Ultimately, the success of transferability of competencies developed during training to real work conditions, will be judged when the pre-service teachers take up their posts in real schools.

Question 6. How will the PBL strategy used by the pre-service technology teachers impact on the learning quality and attitudes of learners?

The experimental and control groups had the same averages for the pre- and the post-tests. The experimental group learners did not outperform control group learners in the test. However, they did score significantly better in two higher cognitive and one low cognitive question than the control group learners, while the control group learners performed better in two low cognitive questions. The post-test performance of the experimental learners was significantly higher than their pre-test, while this is not true for the control group. Based only on the empirical test results, it seems that PBL maintains quality of learning as it manifests in traditional tests and that it has the potential to enhance higher cognitive performance as far as it can be measured through traditional tests.

In terms of qualitative feedback, it was reported that learners from the experimental group were involved in group debates and discussions which evoked meta-cognitive processes. The pre-service teachers also commented on the value of co-operative learning during their training period. One pre-service teacher said that the PBL has inspired creative thinking, which was something that she could never do before. The solution to the problem prepared by the learners, as well as the presentation thereof, provided learners with the opportunity to express their creativity and own initiative. One group presented their solution to the delegation from the Department of Minerals and Energy in the format of a television programme which reported on environmental news ("50/50" – a popular South African produced programme) and new technologies ("Beyond 2000"). Another group did not only design and build a biogas maker, but executed the task way beyond the minimum specifications and criteria. They actually designed and built an effective burner for their device. It seems that the spirit and purpose of PBL and technology education, which is *inter alia* to provide freedom to explore and to seek creative solutions, were also transferred to real classrooms.

In summary, if the improvement of quality of learning as it occurred through PBL, is defined as outperforming learners who had traditional teaching, on a knowledge test, then the quality of learning occurring through PBL was maintained and not enhanced on average. It was, however, enhanced in two of the questions classified as higher-order questions. PBL was also responsible for the fact that the post-test score was significantly higher than the pre-test score. In traditional teaching, the pre- and post- test scores did not differ significantly. If quality learning is defined as demonstration of creative problem-solving, using initiative, and debating the advantages and disadvantages of various solutions with peers, then PBL did enhance the quality of learning.

The general attitudes of the school learners were positive towards PBL. The minority of learners who did seem to be negative had comments to make about the co-operative members not pulling their weight, rather than the fact that they had to solve a technological problem. The perceived negative attitudes can on the other hand also be ascribed to the fact that learners are forced out of their comfort zones into taking responsibility, intellectual and physical action.

Finally, it should also be realised that there are competencies which can only be fine tuned through experience in the real workplace. Every teacher training programme should, however, operationalise and experiment with curriculum, teaching approaches, strategies and assessment methods which will prepare prospective teachers as best as possible for transfer of competencies to the authentic situation.

6.4 Assessment of the OBE-PBL model to answer the overarching research question

The answer to research question 4 will be revisited now to determine if an OBE-PBL model is a suitable, effective model to use in the training of pre-service technology educators. Having presented all the results in Chapter 5 and discussing them in Chapter 6, a set of criteria will be presented against which the OBE-PBL model will be assessed by the researcher. A five point scale will be used to indicate the extent to which a particular criterion had been met.

The scale has the following meaning:

1: Did not meet the criterion at all.

2: Just not good enough to meet the criterion.

3: Met the criterion.

4: Met the criterion and added some extra value.

5: Exceeded the criterion.

Criteria for determining the suitability and effectiveness of the OBE-PBL model	**1**	**2**	**3**	**4**	**5**
Criteria directly related to pre-service teachers					
1. Transferal of competencies related to facilitating learning through PBL.					√
2. Transferal of competencies related to facilitating learning using co-operative learning strategies.			√		
3. Transferal of competencies related to diagnosing and adapting facilitation strategies to address individual or a group's learning needs.	√				
4. Demonstrate an in-depth understanding of OBE principles.		√			
5. Demonstrate selected outcomes in the curriculum for technology education.			√		
6. Demonstrate an in-depth understanding of the nature, structure and rationale for technology education.			√		
7. Pre-service teachers value the OBE-PBL model as a training strategy for individual development and capacity building.					√
8. Pre-service teachers value the OBE-PBL model as a training strategy that prepared them for the challenges of real classrooms.				√	
9. Pre-service teachers value the OBE-PBL model as an appropriate model for facilitating learning in technology.				√	

10. Show a positive attitude towards the OBE-PBL model.					√
11. Other role-players in the school (principal, science teachers, parents) show interest in the work of the pre-service teacher.				√	
Criteria related to the learners with whom the pre-service teachers intervened					
1. The post-test of the experimental group was significantly better than their pre-test.			√		
2. The post-test of the experimental group was significantly better than post-test of the control group.		√			
3. The majority of learners valued their OBE-PBL experience.			√		
4. The majority of learners had a positive attitude towards their OBE-PBL experience in general.			√		
5. The majority of learners had a positive attitude towards their co-operative learning experience.		√			
6. Learners were challenged by the PBL task.			√		
7. Learners were intensively and actively busy during the execution of the PBL task.					√
8. Learners demonstrated progression in their problem-solving skills			√		
9. All the learners completed a design portfolio and demonstrated their technological devices.		√			
10. Learners were enthusiastic and motivated by the PBL task.				√	

11. Learners demonstrated higher cognitive thinking skills and meta-learning skills.			✓		
TOTAL:	**1**	**4**	**9**	**4**	**4**

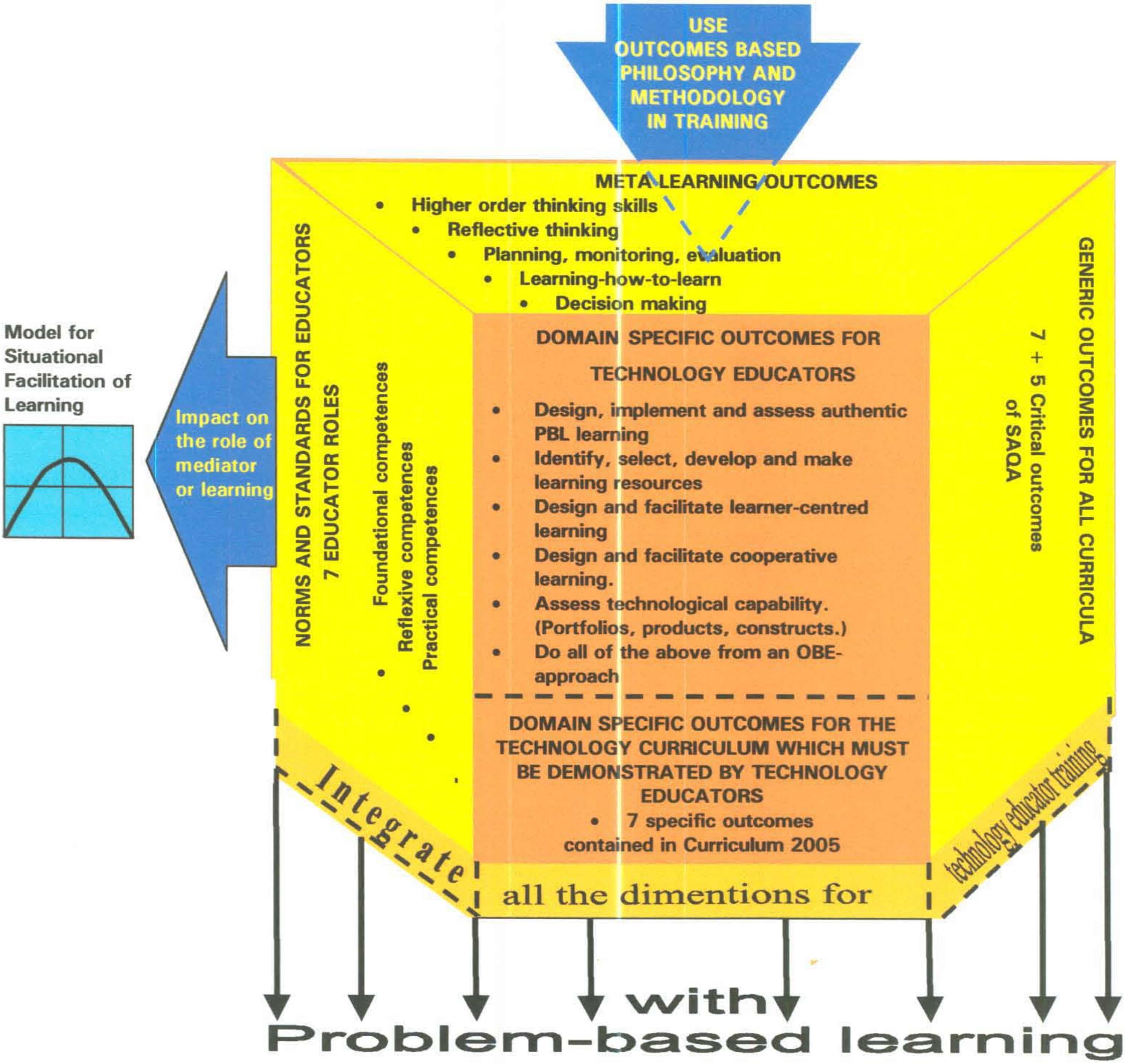
The assessment table confirms that the OBE-PBL model has a multiplicity of dimensions and variables that influence the suitability and effectiveness of the OBE-PBL model for pre-service training of teachers for and outcomes-based technology curriculum. Some of the criteria have been exceeded, some met and some have not been met at all. Once all the criteria can be met, or preferably exceeded, can the OBE-PBL model be declared as suitable and effective for the purpose it was designed for. The next section recommends a refinement of the OBE-PBL model and particularly addresses the criterion that had not been met at all.

6.5 Recommendations for refinement of the OBE-PBL model

This section will recommend a model which can be incorporated into the OBE-PBL model which might assist to bridge the shortcoming that some of the pre-service teachers seemed to have. The particular shortcoming refers to the fact that the OBE-PBL model did not provide teachers with the theoretical background on how to interpret and implement direct instruction within the context of OBE.

Various reasons may be provided for why the proposed model was not initially included in the literature review which was used to shape and design the OBE-PBL model: (a) the original literature review led to the development of the OBE-PBL model that was believed for various valid reasons to be appropriate, (b) this model was tested through research on two levels during training and implementation by trainees and found to have some shortcomings which could not be foreseen during its design stages (c) this led to a focused search for proven ways to improve the OBE-PBL model – including reviewing at literature that was not specifically aimed at teachers or teacher educators. In this process, the Hersey & Blanchard Situational Leadership Model (1982) was discovered which was originally developed and implemented in the field of management and leadership development. This additional model will branch off from the left façade of the original OBE-PBL model describing the seven educator roles, especially the mediator of learning role. See Figure 6.1 for the refined OBE-PBL model.

Figure 6.1: The refined



This particular role encompasses the competencies related to the act of facilitating learning, where some pre-service teachers had a narrow view on their functions as learning facilitator. The model referred to was one adapted from a model used in the post-modern diverse and heterogeneous contexts in business and industry.

A domain which has also explored many theories and models of *effectively managing* the diverse needs and differences in human resources in business and industry, is that of industrial psychology. Hersey & Blanchard (1982:xv) comment as follows regarding the search for appropriate management behaviour and interventions:

> *For a long time management theory has been characterised by a search for universals – a preoccupation with discovering essential elements of all organizations. The discovering of common elements is necessary, but they do not really provide practitioners with "principles" that can be applied with universal success.*
>
> *In the past decade there has appeared a relative maturity in this field as it begins to focus on "patterned variations" – situational differences. We assume that there are common elements in all organizations, but we also assume differences among them and in particular the managing of their human resources.*

Hersey & Blanchard (1982) have presented a model called the Situational Leadership Model which can assist in the "how to" skills of managing or facilitating the diverse needs in a classroom. Of their model they say that it is a *"practical model that can be used by managers, salespeople, teachers and parents to make the moment-by-moment decisions necessary to effectively influence other people".*

In this study the teacher as learning facilitator is seen as the manager of the learning situation and the learners in that situation. This model, when internalised and practised by teachers, has the potential to serve as a framework to skillfully manage the creative tension in an individual learner or group. The Situational Leadership Model by Hersey & Blanchard (1982) will be adapted slightly within a learning context and will be labelled the "*Situational Learning Facilitation Model.* Furthermore, instead of the terminology "manager" and "follower", the terms "facilitator" and "learner" will be used.

Guidelines for interpreting the model

Situational Facilitation is based on an interplay among

1. the amount of guidance and direction (task behaviour) a facilitator gives, related to a specific learning task;

2. the amount of emotional support (relationship behaviour) a facilitator provides;

3. the readiness or maturity level learners exhibit in performing a task, function or activity.

Task behaviour is described as the extent to which a facilitator engages in spelling out the responsibility or next steps to a learner or a group. These behaviours might include telling a learner what to do, how to do it, where, when and who is to do what at a particular point in the situation or process.

Relationship behaviour can be described as the extent to which a facilitator engages in two-way or multi-way communication. These behaviours include listening, as well as different types of supportive behaviour.

Learner maturity or readiness is defined as the extent to which a learner has the capacity and willingness to set high, but attainable goals and to accomplish a task or parts thereof (Hersey & Blanchard, 1980:44). Maturity in this context is **not** an indication of a learner's values, personal characteristics or age. Two main components of maturity are **ability** and **willingness**. Ability comprises of the knowledge, skills and experience an individual learner or group possesses to perform a particular task or activity. Willingness refers to the extent to which an individual or group has the confidence, commitment and motivation to accomplish a specific task or activity. These variables of maturity should be considered only in relation to a specific situation or particular task, and not in a total sense. All learners tend to be more or less mature in relation to a particular task. A learner may be very mature when she has to do a search for research materials on the world wide web or library, but when it comes to the paperwork of compiling her portfolio and sharing her research materials with other group members, she might be very immature.

A diverse group of learners in a class, will have varying degrees of maturity (readiness) levels. This reality demands that learning facilitators should identify (diagnose) the varying degrees of maturity levels learners are functioning on. Consequently, the learning facilitator will need to display various degrees of task and/or supportive behaviour to manage the gap for creative tension. According to the model, learners may be identified to be functioning on four different levels on the continuum of maturity, where level M1 is least mature level M4 the highest in maturity.

- M1 refers to very **low levels of maturity** (unwilling or insecure and unable).
- M2 represents **low to moderate levels of task-relevant maturity** (willing or confident but unable).
- M3 is **moderate to high levels of task-relevant maturity** (able but unwilling or insecure).
- M4 is **high levels of maturity** (willing and able).

Each of these levels of maturity is best managed by a learning facilitation style that corresponds with the maturity level of a learner or group for a particular task. The four facilitation styles are represented in four quadrants on the two dimensional graph. Style S1 will be the high probability style for maturity level M1. When a learner is extremely low in both dimensions of maturity – unable and unwilling (M1)- the high probability style is S1. The learning facilitator provides directive behaviour and guidance (telling), **but not to the extent that the learner is spoonfed and disempowered**. The learning facilitator must still manage the gap so that creative tension is maintained. It is always the ultimate goal of the learning facilitator that the learner becomes independent from him as soon as possible, so that the learner can become a responsible, autonomous life-long learner (able and willing).

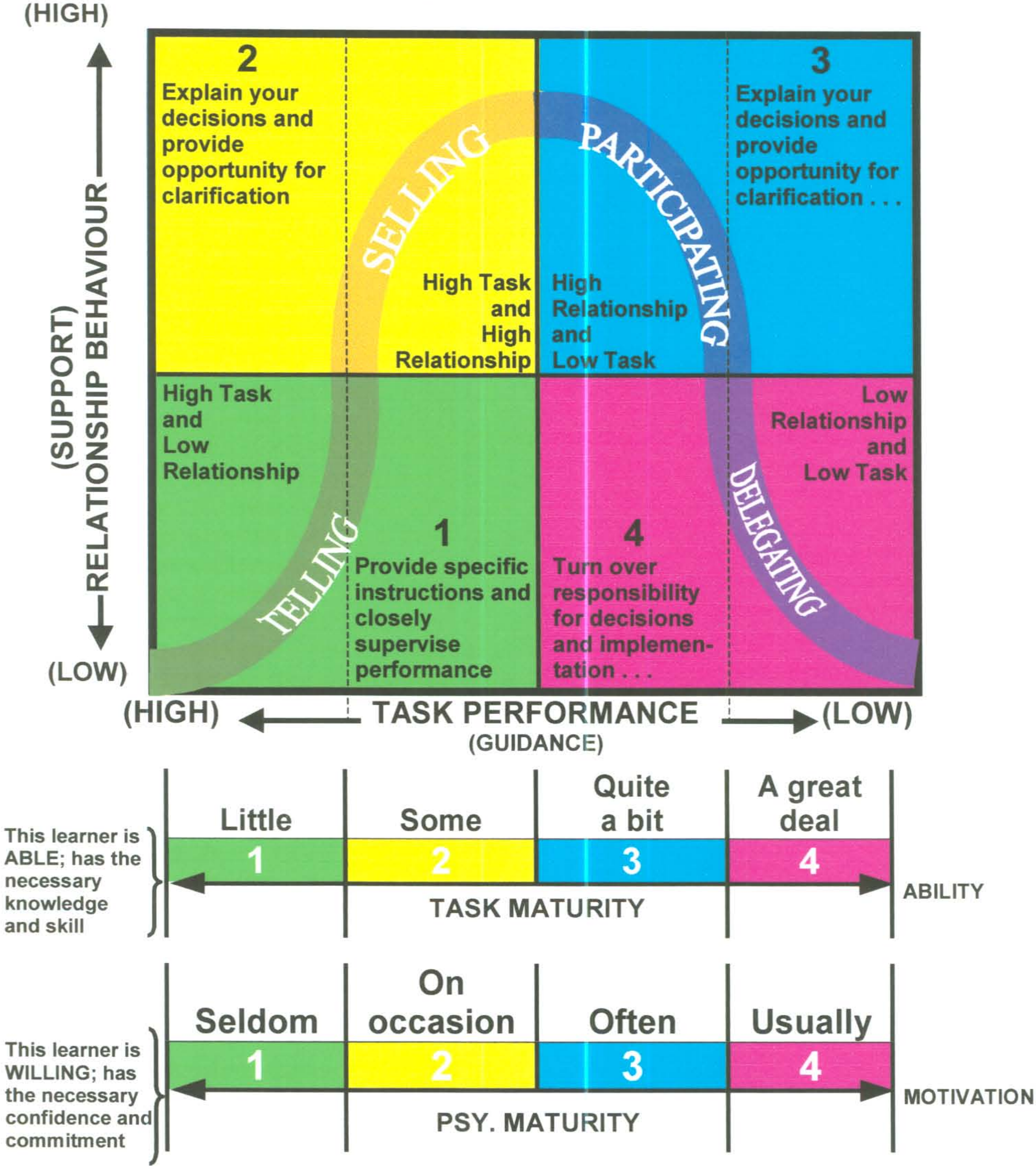
As the level of maturity of learners continues to increase in terms of accomplishing a particular task, facilitators should begin to reduce task behaviour and increase relationship behaviour until they reach a moderate level of maturity. As learners begin to move into an above-average level of maturity, it becomes appropriate for facilitators to decrease not only task behaviour, but also relationship behaviour. When learners have reached a M4 level of maturity, they are able in their task performance, but also display psychological maturity. Socio-emotional support and task direction are no longer necessary and the facilitator can adopt a style of delegation, which is a positive indication of trust and confidence. In another task a learner may slip back to a M3 or M2 level of maturity and the facilitator will need to correspond with the appropriate facilitation style (Hersey & Blanchard, 1980:45-46).

The aforementioned explanation about the Situational Learning Facilitation Model can be summarised as follows before the model is presented:

Level of maturity of learner	**Style of learning facilitator**	**Description of task and relationship behaviour**
M1: Unable and unwilling	**S1:** Telling	The focus is on high task support and lower relationship
M2: Unable and willing	**S2:** Selling	High task and high relationship
M3: Able and unwilling	**S3:** Participating	Low task and high relationship
M4: Able and willing	**S4:** Delegating	Low task and low relationship

SITUATIONAL LEARNING FACILITATION

FACILITATOR BEHAVIOUR



This model will be dealt with in a PBL way when future pre-service teachers will be dealing with problems represented by the mediator and facilitator of learning dimension in the OBE-PBL model.

6.6 Limitations in the research design

The two-level study reported in this thesis produced a number of findings that have important implications for teacher trainers. However, future researchers who may wish to extend this line of research need to be cognizant of the methodological limitations of the study. The major limitations are highlighted below.

Every researcher attempts to design the most effective research plan and implement methodologies, which will allow him/her to make scientific knowledge claims within the constraints of a particular context. The findings of the present study can only be generalised to PBL programmes which concentrate on professional teacher training/education for OBE in technology and science Learning Areas. An important qualification to be made about the present results on the classroom level, is that it is subjected to all the general limitations common to classroom-based research, which is restricted to characteristics of school, staff, governing bodies and learners. One of the restrictions with pre-service teachers working at various sites, geographically far apart for example, is that the researcher could not be present with each pre-service teacher during the full period of their teaching in the schools. This had the implication that the researcher had to rely on the data which could be gathered from interviews, log-books, learner test results and demonstrations of the problem-solution, rather than direct observation, to gather evidence on whether the competencies cultivated in the university classroom were transferred to the real workplace. This might limit the validity of data. While all of the restrictions may constrain the interpretations of the findings, they are balanced by the value of the complexities of a real classroom investigation which provides added authenticity that more carefully controlled laboratory studies lack.

When reflecting on the implemented research design, possible adjustments, which may add value to future research, may be considered. Implementing the interventions with the pre-service teachers and learners over a longer period of time will probably, but not necessarily, yield more reliable and generalisable results. The time limitation, which was only six months, on the OBE-PBL training programme meant that pre-service teachers could not be trained to develop a strong theoretical understanding of OBE, with the consequence that some of them did not address the learning needs of some of the learners while facilitating learning. In future research, if the OBE-PBL model is to be used in the subject-didactics methodology course, which is supposed to more practical, integrating knowledge and skills across all the subjects that pre-service teachers take and in the same timespan, then it should be negotiated with other subject organisers that the theoretical aspects of OBE should be addressed in detail in the theoretical subjects.

Larger numbers of respondents participating in research also contribute to validity and reliability of data. Unfortunately larger numbers of pre-service teachers were not available. To address the problem of small numbers of pre-service teachers who enroll for the subject-didactics course in science will not be an easy one to solve. As was discussed in Chapter 1, Section 1.3.2.4, the number of learners (students) enrolling for science education is at crisis low levels. A course for technology education which came into existence as a result of this research in 2000, has similar problems of low enrolment. Numbers of students might still increase in the second year that this course will be offered. Fourteen students enrolled for the BEd (Honours) course in technology education in 2000, which was four times as many as for the natural science methodology course. Follow up research may be conducted with large numbers of pre- and in-service teachers who want to be retrained as technology teachers since the inception of OBE, where subjects have merged to form Learning Areas and teachers are faced with the possibility of losing their jobs.

This research represents a single step in what should be a much larger research agenda to investigate the effectiveness of PBL as a curriculum renewal, teaching and learning strategy for outcomes-based education.

6.7 Recommendations for future research in PBL

The results of the present research suggest a number of directions that might be taken in future research into technology teacher training in general and PBL in particular. Such research could be divided into three categories: replications of the present research using modified methodology to overcome limitations of the present research; direct extensions of the present research to encompass new ideas; and attempts to answer new questions that were raised by this study. The recommendations will be discussed under these three categories.

6.7.1 Replications of the present research using modified methodology to overcome limitations of the present research

- ***Obtaining results from learners***

In this research, the learners wrote a pre- and post-test based on content knowledge and skills where questions were classified according to the cognitive taxonomy of Bloom. To obtain additional information about the development of higher cognitive thinking and meta-learning through PBL, a standardised instrument may be identified or even developed which can provide information of this nature. Such an instrument should not be dependent on content knowledge and skills and may be used in a pre- and post-test design to determine the impact of PBL on higher order thinking skills. The LEMOSS instrument may be used as it is, or even be adapted for different Learning Areas to provide information on categories related to higher order thinking skills and learner motivation.

- ***Obtaining results from pre-service teachers to determine transferability of competencies from training classroom to the real workplace***

In this research, information was obtained from the learners with whom the pre-service teachers intervened as well as from the pre-service teachers themselves by means of interviews to determine inter alia whether pre-service teachers could transfer competencies to real classrooms. As mentioned earlier, direct and continuous observation of the classroom interventions conducted by the pre-service teachers can contribute to enhancing the validity of the data which answer this question. An observation schedule containing a set of transferable performance criteria can be developed which can be used either by the researcher herself or by external, independent observers.

6.7.2 Direct extensions of the present research to encompass new ideas

- ***Evaluation of the "Situational Learning Facilitation Model"***

After the design, implementation and evaluation of the OBE-PBL model, a shortcoming was identified. Based on the literature with regard to the Situational Leadership Model which was adapted and called the Situational Facilitation Model, it is hypothesised that this model will bridge the shortcoming in the OBE-PBL model. This hypothesis needs to be tested during the training of pre-service teachers and during their practical interventions in real classes.

6.7.3 Related research that was not prompted by the current research

- ***Assessment practices and instruments to assess learning that occurred through PBL***

Research is needed to identify which assessment practices, strategies and instruments will be most reliable and effective to use in a PBL environment. If only traditional assessment practices and instruments are implemented to assess learners who have learnt through PBL, the impact and outcomes demonstrated as a result of learning through PBL might not even be observed. Traditional assessment might not be valid or reliable for learning which occurs as a result of PBL. Both quantitative and qualitative approaches need to be considered when assessing learner outcomes. Research questions which may be considered can include the following:

- Which assessment strategies and instruments can be used to assess the quality of meta-learning, meta-reasoning, reflective thinking, decision-making and creative thinking, which are outcomes of PBL?
- Which learning theories and cognitive development theories are more appropriate and/or underpin assessment in PBL?

6.7.4 New research questions that were raised by this study

- ***Management of PBL in large classes***

The OBE-PBL model was implemented in one course in the Higher Education Diploma with a small number of 20 pre-service teachers of whom 6 facilitated learning in school classrooms. Since the OBE paradigm is also compulsory for tertiary institutions, more and more courses (also meaning subject) are looking at PBL to organise the entire curriculum or at least some courses in the curriculum. Not all the courses deal with small numbers of learners as was the case in this research. Courses dealing with at least 500 learners per course are also interested to explore the educational possibilities of PBL, but are rightfully concerned about the practical management of PBL in large groups. Extensive research should be undertaken to gather information on the following aspects related to tutors:

- What is the role and function of tutors in managing effective PBL curricula in large classes?

- What is the role and function of the lecturer who is responsible for a course and the tutors who are allocated to that course?

What type of training would be appropriate for tutors to effectively facilitate learning in the groups they work with?

- What is the profile (criteria and characteristics) of a successful PBL tutor?

- ***PBL for distance delivery of education***

Research needs to be done to determine how PBL may be used for distance education and training delivery. The trend at the university where this research was undertaken, is to increasingly convert to telematic education delivery modes. This means that apart from contact sessions with learners, electronic technology such as the world wide web, e-mail, paper-based or inter-active television will be used to deliver education to learners locally and internationally. The impact of PBL on the quality of learning through telematic delivery mechanisms, also needs to be assessed. A typical research question to be researched may be the following:

- Is PBL an effective approach to use in delivering distance education or will traditional highly structured curricula and teaching strategies be more effective for the distance learner?

- ***The effect of PBL on learning in semi-rural and rural schools in South Africa***

The pre-service teachers implemented the OBE-PBL model in schools which are well resourced and where learners have access to resources beyond the resource kit and local school library. This resource situation in semi-rural and rural schools in South Africa's remote areas, are very different from that of urban and sub-urban schools. The fact remains that all the schools and teachers in South Africa have to implement the new curriculum with the new Learning Area, technology education, from an outcomes-based perspective. A research questions which may be considered is:

- How can PBL be used as a strategy to operationalise OBE in semi-rural and rural schools in South Africa?

- ***The impact on the quality of learning and professional preparation if an entire qualification's curriculum is designed according to PBL principles***

In this research, the PBL curriculum design and strategy was used in one of eleven subjects, also called courses, which the pre-service teachers have to enroll for and pass, to qualify for their Higher Education Diploma. In this research, the curriculum of the subject called subject-didactics for the Natural Sciences, was organised around problems and taught through PBL. Research questions that may be considered are the following:

- What is the impact on transferability of competencies and quality of professional preparation of pre-service high school teachers if an entire qualification's curriculum is designed according to PBL principles?

- Should PBL be used for educating pre-service teachers in all subjects/courses and is PBL an appropriate strategy to use in various subjects/Learning Areas which have natures and structures?

These questions and recommendations will contribute to explore the promises, lessons to be learnt and breakthroughs in adopting and adapting PBL in general, and in the context of OBE and science-technology education.

6.8 Summary

This study has explored and researched the power of active, learner-centred learning made possible through PBL. The transformation in South African education is built on the principles of OBE. With the transformation, also came a new Learning Area, namely technology education, in the outcomes-based Curriculum 2005. A dual responsibility came to the trainers of teachers: to prepare pre-service teachers with the competencies for technology education, as well as to do it within an OBE framework. The OBE-PBL model was constructed and implemented in the pre-service training of final year science teachers who also have to facilitate technology education as part of the natural science Learning Area in the new curriculum. The internalisation and implementation of the OBE-PBL model by the pre-service teachers were tested in real schools, and results obtained helped to reflect on the strengths and weaknesses in the quality of the pre-service training programme.

As a result of the reflection, a shortcoming in the pre-service training programme was identified. This shortcoming will intentionally be addressed in future training programmes for pre-service technology educators who have to facilitate learning within an OBE framework. The Hersey & Blanchard model, which has been called the Situational Learning Facilitation Model, will also be included in the curriculum. The fact remains that the challenge of preparing future teachers for post-modem classrooms of the world, is a real one facing higher institutions mandated for this task.

This research has actively attempted to find and demonstrate innovations in practice which are desperately needed in the light of the new outcomes-based paradigm. The Educational Policies and Acts inform us that education should get a new face. On paper the face of education has already changed dramatically. Operationalising the blueprint documents at a practical micro level where millions of South African learners have to work towards maximising their own potential and that of their country, is the challenge for teachers. An obvious place to initiate the change process is in the pre-service teacher training classes. Teachers should be trained the way they are expected to teach. This research attempted to add value to the inquiry and discourse on outcomes-based practice, in the new Learning Area of technology education. As for the vision of the new education system based on OBE which is life-long learning, it is sincerely hoped that the pre-service teachers who have experienced PBL on various levels will embrace the spirit of transformational OBE which is

education must not be seen as a preparation for life, it is life in all facets of simplicity and complexity.

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Appendix 1

The 66 specific outcomes for the eight learning areas

LEARNING AREAS

Arts and Culture	Human and Social Sciences	Life Orientation	Economic and Management Sciences	SPECIFIC OUTCOMES
1. Apply knowledge, techniques and skills to create and be critically involved in arts and culture processes and products.	1. Demonstrate a critical understanding of how South African society has changed and developed.	1. Understand and accept themelves as unique and worthwhile human beings	1. Engage in entrepreeurial activities.	
2. Us the creative processes of art culture to develop and apply social and interactive skills.	2. Demonstrate a critical understanding of patterns of social development.	2. Use skills and display attitudes and values that improve relationships in family, group and community.	2. Demonstrate a personal role in the economic environment.	
3. Reflect on and engage critically with arts experience and works.	3. Participate actively in promoting a just, democratic and equitable society.	3. Respect the rights of people to hold personal beliefs and values.	3. Demonstrate the principles of supply and demand and the practices of production.	
4. Demonstrate an understanding of the origins, functions and dynamic nature of culture.	4. Make sound judgements about the development, utilisation and management of resources.	4. Demonstrate value and respect for human rights as reflected in *ubuntu* and other similar philosophies.	4. Demonstrate managerial expertise and administrative proficiency.	
5. Experience and analyse the role of the mass media in popular culture and its impact on multiple forms of communication and expression in the arts.	5. Critically understand the role of technology in social development.	5. Practise acquired decision making skills.	5. Critically analyse economic and financial data to make decisions.	
6. Use art skills and cultural expressions to make an economic contribution to self and society.	6. Demonstrate an understanding of inter-relationships between society and the natural environment.	6. Access career and other opportunities and set goals that will enable them to make the best use of their potential and talents.	6. Evaluate different economic systems from various perspectives.	
7. Demonstrate an ability to access creative art and cultural processes to develop self-esteem and promote healing.	7. Address social and environmental issues in order to promote development and social justice.	7. Demonstrate the values and attitudes necessary for a healthy and balanced lifestyle.	7. Demonstrate actions which advance sustained economic growth, reconstruction and development in South Africa.	
8. Acknowledge, understand and promote historically marginalised arts and cultural forms and practices.	8. Analyse forms and processes of organisations.	8. Evaluate and participate in activities that demonstrate effective human movement and development.	8. Evaluate the interrelationships between economic and other environments.	
	9. Use a range of skills and techniques in the human and social sciences context.			

LEARNING AREAS

SPECIFIC OUTCOMES	Language, Literacy and Communication	Mathematical Literacy and Mathematics	Natural Sciences	Technology
	1. Make and negotiate meaning and understanding.	1. Demonstrate an understanding about ways of working with numbers.	1. Use process skills to investigate phenomena related to the natural sciences.	1. Understand and apply the technological process to solve problems and satisfy needs and wants
	2. Show critical awareness of language use.	2. Manipulate number patterns in different ways.	2. Demonstrate the acquisition of knowledge and an understanding of concepts and principles in the natural sciences.	2. Apply a range of technological knowledge and skills ethnically and responsibly
	3. Respond to the aesthetic, affective, cultural and social values in texts.	3. Demonstrate an understanding of the historical development of mathematics in various social and cultural contexts.	3. Apply scientific knowledge and skills to problems in innovative ways.	3. Access, process and use data for technological purposes.
	4. Access, process and use information from a variety of sources and situations	4. Critically analyse how mathematical relationships are used in social, political and economic relations	4. Demonstrate an understanding of how scientific knowledge and skills contribute to the management, development and utilication of natural and other resources.	4. Select and evaluate products and systems
	5. Understand, know and apply language structures and conventions in context.	5. Measure with competence and confidence in a variety of contexts	5. Use scientific knowledge and skills to support responsible decision making	5. Demonstrate an understanding of how different societies create and adapt technological solutions to particular problems
	6. Use language for learning.	6. Use data from various contexts to make informed judgements.	6. Demonstrate knowledge and understanding of the relationship between science and culture.	6. Demonstrate an understanding of the impact of technology.
	7. Use appropriate communication strategies for specific purposes and situations.	7. Describe and represent experiences with shape, space, time and motion using all available senses.	7. Demonstrate an understanding of the changing and contested nature of the natural sciences.	7. Demonstrate an understanding of how technology might reflect different biases and create responsible and ethical strategies to address them.
		8. Analyse natural forms, cultural products and processes as representations of shape, space and time.	8. Demonstrate knowledge and understanding of ethical issues, bias and inequities related to the natural sciences.	
		9. Use mathematical language to communicate mathematical ideas, concepts, generalisations and thought processes.	9. Demonstrate an understanding of the interaction between the natural sciences, technology and socio-economic development.	
		10. Use various logical processes to formulate tests and justify conjectures.		

Appendix 2

The breakdown of competencies for each of the seven educator roles

ROLE: LEARNING MEDIATOR
Practical competencies:
Using key strategies such as higher level questioning, problem-based tasks and projects; and appropriate use of group work, whole class teaching and individual self-study.
Adjusting teaching strategies to: Match the developmental stages of learners, meet the knowledge requirements of the particular learning area; cater for cultural, gender, ethnic, language and other differences among learners.
Using media and everyday resources appropriately in teaching including judicious use of: common teaching resources such as text-books, chalkboards and charts; other useful media like over head projectors, computers, video, audio etcetera.; popular media and resources, like newspapers, magazines and other artefacts form everyday life.
Foundational competencies:
Understanding the pedagogic content knowledge – the concepts, methods and disciplinary rules- of the particular learning area being taught.
Understanding the learning assumptions that underpin key teaching strategies and that inform the of media to support teaching
Reflexive competencies:
Defending the choice of learning mediation action undertaken and arguing why other learning mediation possibilities were rejected.
Reflecting on how teaching in different contexts in South Africa effects teaching strategies and proposing adaptations.

ROLE: INTERPRETER AND DESIGNER OF LEARNING PROGRAMMES AND MATERIALS
Practical competencies:
Adapting and/or selecting learning resources that are appropriate for age, language competencies, culture and gender of learner groups.
Designing original learning resources including charts, models, worksheets and more sustained learning texts.
Foundational competencies:
Understanding the principles and practices of OBE, and the controversies surrounding it, including debates around competence and performance.
Understanding the learning area to be taught, including appropriate content knowledge, pedagogic content knowledge, and how to integrate this knowledge with other subjects.

ROLE: LEARNING AREA/SUBJECT/DISCIPLINE/PHASE SPECIALIST
Practical competence
Adapting general educational principles to the phase/subject/learning area.
Selecting, sequencing and pacing content in a manner appropriate to the phase/subject/learning area; the needs of the learners and the context.
Selecting methodologies appropriate to learners and contexts.
Integrating subjects into broader learning areas and learning areas into learning programmes.
Assessing in a manner appropriate to the phase/subject/learning area.
Teaching concepts in a manner which allows learners to transfer this knowledge and use it in different contexts.
Foundational competence:
Understanding the assumptions underlying the descriptions of competence in a particular discipline/-subject/learning area.
Understanding the ways of thinking and doing involved in a particular discipline/subject/learning area and how these may be taught.
Knowing and understanding the content knowledge of the discipline/subject/learning area.
Knowing of and understanding the content and skills prescribed by the national curriculum.
Understanding the difficulties and benefits of integrating this subject into a broader learning area.
Understanding a range of assessment approaches appropriate to the learning area/subject/discipline/phase/sub-field
Understanding the role that a particular discipline/subject/learning area plays in the work and life of citizens in South African society – particularly with regard to human rights and the environment.
Reflexive competence:
Reflecting on and assessing own practice.
Analysing lesson plans, learning programmes and assessment tasks and demonstrating an understanding of appropriate selection, sequencing and pacing of content.
Identifying and critically evaluating what counts as undisputed knowledge, necessary skills, important values.
Making educational judgements on educational issues arising from real practice or from authentic case study exercises.
Researching real educational problems and demonstrating an understanding of the implications of this research.
Reflecting on the relations between subjects/ disciplines and making judgements on the possibilities of integrating them.

Appendix 3

The specific outcomes, assessment criteria and range statements for technology education in Curriculum 2005 for the senior phase

SPECIFIC OUTCOME 1: UNDERSTAND AND APPLY THE TECHNOLOGICAL PROCESS TO SOLVE PROBLEMS AND TO SATISFY NEEDS AND WANTS

The technological process refers to the cycle of investigating problems, needs and wants and the designing, developing and evaluating of solutions in the form of products and systems. The technological process is the basis of all technological endeavours. An understanding of the process is fundamental to the acquisition of technological literacy. The technological process is an integrated and indivisible one and therefore assessment should apply to the whole process.

ASSESSMENT CRITERIA	RANGE STATEMENT
	At this level learners should show detailed, logical and articulate work indicating understanding of the integrated nature of the technological process. Learners should engage in processes of: • investigating (research) • planning and designing • developing (constructing, making, modelling) • evaluating (measuring, testing, deciding) Learners should apply the technological process in respect of the following South African and global themes: housing, textiles, communications, water, transport, food, energy, health, tourism, agriculture, manufacturing, media, sport and recreation; and in the following learning context: Perspective: local, national, international Modes: individual, pair and group work Presentation styles: oral, written, graphical, modelling, products, artefacts and simulation Resources: texts, interviews, observation, experimentation

SPECIFIC OUTCOME 2: APPLY A RANGE OF TECHNOLOGICAL KNOWLEDGE AND SKILLS ETHICALLY AND RESPONSIBLY

Technological knowledge and skills form the backbone of this learning area as it increases the learner's capability to engage confidently with the technological process and within a technological world. This outcome further seeks to develop the learner's ability to apply this acquired knowledge and skills in an ethical and responsible manner.
In this outcome evidence of achievement should show the acquisition of knowledge and skills in respect of the nature, functions and applications of:

- safety; information; materials; energy

in

- Systems and Control; Communication; Structures; Processing.

In practice learners will engage in the above in an integrated way.

ASSESSMENT CRITERIA	RANGE STATEMENT
Learners should present work in which: • knowledge and under-standing of: Systems and Control Communication Structures Processing is reflected • knowledge and understanding of: safety information materials energy as they manifest in Systems and Control • a range of hand and power tools and equipment are used • sensitivity to possible ethical issues and dilemmas is demonstrated • responsible behaviour is demonstrated	Systems and control, communication, structures and processing At this level learners will practice and develop: • investigation skills which include researching, recording, investigating, etc. • design skills which include planning, communicating, graphics, etc. • manipulation skills which include creating and modification according to specifications • evaluation skills including testing, drawing conclusions etc. • sensitivity to problems, dilemmas, issues and choices in society Systems and Control These skills will be applied within an understanding of: • input, process, output • open and closed systems • concepts of technological systems • components and devices • the way signals and information flows in and between systems • the multiple and complex nature of interconnections between and within as well as the control of: mechanical electrical and • hydraulics/pneumatics systems.
	Communication These skills will be applied within an understanding of: • the use of appropriate technical design and development skills, technical language and conventions for product development to meet given purposes and specifications (e.g. layout, printing, graphics and data presentation) Structures These skills will be applied within an understanding of: • Complex, made structures • Reinforcing within – complex made structures – composite materials • Internal and external forces • Simple calculations and formulae associated with volume, force, and other structural theory concepts Context: Shelter, transport, storage, containerisation etc. *Processing:* These skills will be applied within an understanding of: The activity of processing raw materials into refined materials and into products, with waste as a by-product. Processes: • conversion • preservation

	• reduction • combination Context: biotechnology, manufacturing, agriculture, mining ENERGY; MATERIALS; INFORMATION AND SAFETY Learners will develop sensitivity towards, an understanding of and appropriate application skills in the use of energy, materials, information and safety as common features of all technology. *Energy:* • Types and sources • Energy transformation • Energy storage and distribution • Energy as a resource – renewable, available and cost • Application

	Materials:
	
	Sources
	
	• Types – natural, synthetic and composite
	• Techniques
	  – Processing (separating, combining, converting, joining, shaping and forming)
	  – Storage
	  – Preservation
	  – Distribution
	• Properties (physical, chemical and aesthetic)
	• Selection (form, function, potential and suitability)
	• Cost
	
	Waste management of materials

	Information Safety • Housekeeping, organisation and management • Occupational safety • Appropriate behaviour, dress and procedures • Safe use of tools, equipment and materials • First aid Tools and equipment Understanding the operating principles of tools and equipment. Selection, use and maintenance of tools and equipment: • hand tools and power tools • simple and complex • electric, pneumatic, electronic, mechanical • applications (cutting, soldering, cooking, etc.) Learners should apply the Technological process in respect of the following South African and global themes: housing, textiles, communications, water, transport, food, energy, health, tourism, agriculture, manufacturing, media, sport and recreation.

SPECIFIC OUTCOME 3: ACCESS, PROCESS AND USE DATA FOR TECHNOLOGICAL PURPOSES

One of the features of a rapidly changing world is the accumulation of vast amounts of information and data which has an increasing impact on technology and all other aspects of modern life. In order for learners to engage effectively in the Technological Process, they need to be competent and confident in working with various forms of information and data.

ASSESSMENT CRITERIA	RANGE STATEMENT
Learners should produce work in which: • various types of data are accessed • various types of data are processed • various types of data are used	At this level learners should produce work that is articulate, logical and detailed. They should use combinations of data types in an integrated way to investigate, analyse and make decisions. Learners should understand: **Data storage and communication forms:** • verbal/non-verbal • audio • visual • electronic **Data types:** • numerical • text • graphics within the context of the following processes: • access (identify, observe, research, locate etc.) • process (collate, communicate, compare, evaluate etc.) • use (apply, make choices, accept, reject etc.) Learners should apply data for technological purposes in respect of the following South African and global themes: housing, textiles, communications, water, transport, food, energy, health, tourism, agriculture, manufacturing, media, sport and recreation. and in the following Learning Contexts: Perspective: local, national, international Mode: individuals, pairs, groups Presentation: oral, written, graphical, modelling and simulation Resources: texts, interviews, observation, experimentation

SPECIFIC OUTCOME 4: SELECT AND EVALUATE PRODUCTS AND SYSTEMS

All learners are exposed to a wide variety of products and systems. They need to acquire the critical skills necessary to operate as confidently as consumer and users of technology.

ASSESSMENT CRITERIA	RANGE STATEMENT
Learners should be able to present work in which: Products and systems are effectively selected	Learners at this level should produce ? logical and articulate indicating ? selection and evaluation of products and ? Selection and Evaluation

effectively selected Products and systems are effectively evaluated	• under the need • derive and prioritise the constraints ? influence the choice • compare the characteristics and ? range similar products in respect of constraints • test and evaluate products and systems **Products and Systems** • a range from simple to complex designs • a range from simple to complex application • mechanical, electrical and electronic • services (eg postal service) **Constraints and factors** In drawing comparisons learners should factors such as: • costs and value • aesthetics and ergonomics • social • environmental • materials • durability • life expectancy • fit to purpose • availability and maintenance

SPECIFIC OUTCOME 5: DEMONSTRATE AN UNDERSTANDING OF HOW DIFFERENT SOCIETIES CREATE AND ADAPT TECHNOLOGICAL SOLUTIONS TO PARTICULAR PROBLEMS

Technology is interwoven with the economic, social and cultural fabric of societies. These and other factors have influenced the way technology has evolved in different places and at different times. Learners need to understand the complex and diverse ways in which technology evolves.

ASSESSMENT CRITERIA	RANGE STATEMENT
Learners should be able to present work in which: • Various factors are considered • Different technological solutions are compared • New solutions are predicted? • Causal relationships between main factors influencing technological development are reflected upon • A variety of perspectives, modes, presentations and resources are used	Learners at this level should show detailed, logical and articulate work which reflects: ***Content*** • historical • geographical • cultural • economic ***Process*** • research • observation • analysis ***Context*** Perspective: local, national, international Mode: individuals, pairs, groups Presentation: oral, written, graphical, modelling and simulation Resources: texts, interviews, observation, experimentation

SPECIFIC OUTCOME 6: LEARNERS WILL DEMONSTRATE AN UNDERSTANDING OF THE IMPACT OF TECHNOLOGY

Human values and other factors influence technology. Technology in turn shapes and influences the nature and well being of society, the economy and the natural environment, in both intended and unintended ways. Learners need to appreciate the ways in which technology effects all aspects of life. Outcomes 6 and 7 should preferably be achieved by integrating them with tasks and activities designed to achieve outcomes 1 to 5.

ASSESSMENT CRITERIA	RANGE STATEMENT
Learners should be able to present work in which: • technological impact in a variety of contexts is reviewed	At this level learners should be able to research, analyse and draw conclusions and make predictions about the positive and/or negative impact of technology in the following: **Contexts** • society • the environment • the economy; **Perspectives** • local • national and • global **Time scales** • short • medium and • long term **Consequences** • intended and • unintended nature

SPECIFIC OUTCOME 7: LEARNERS WILL DEMONSTRATE AN UNDERSTANDING OF HOW TECHNOLOGY MIGHT REFLECT DIFFERENT BIASES AND CREATE RESPONSIBLE AND ETHICAL STATEGIES TO ADDRESS THEM

During the course of human history technology has been used to both promote and counter bias. Bias has also influenced the development and use of technology. Learners need to be aware of these relationships and aware of possible bias in their involvement in technological activities.
Outcomes 6 and 7 should preferably be achieved by integrating them with tasks and activities designed to achieve outcomes 1 to 5.

ASSESSMENT CRITERIA	RANGE STATEMENT
Learners should be able to present work in which: • The concept and types of biases are understood and identified. • Biases limiting access to and the application of technology are identified. • Strategies to address biases are developed.	*At this level learners should:* • understand the nature and causes of bias • be sensitive to and understand the complex ways in which bias affects important groups such as – gender – race – age – disability At this level learners should: • research and analyse how access to and benefits of technology have been denied to various groups. • understand the impact of this bias on such groups. • understand how the use and application of technology reflects, interests, priorities and biases in society At this level learners should identify existing and suggest possible strategies to counter biases and address their affects.

APPENDIX 4

Attitude questionnaire for the experimental group

ATTITUDE QUESTIONNAIRE FOR THE EXPERIMENTAL GROUP

Surname and Name: .... Respondent Number: ......

Encircle the number of your choice. Eg. 1 2 (3) 4 5

Numbers 1 to 5 have the following meaning:

1 = Not at all

2 = Not too much

3 = I don't know

4 = Quite a lot

5 = Very much

		Not at all	Not too much	I don't know	Quite a lot	Very much
1	Did you learn anything valuable from this particular task?	1	2	3	4	5
2	Was the research kit of any help to you?	1	2	3	4	5
3	Did you make use of the research checklist which was part of the kit?	1	2	3	4	5
4	Do you enjoy this new method in the teaching of a subject?	1	2	3	4	5
5	Do you think it is valuable to work in small groups with fellow learners?	1	2	3	4	5
6	Do you prefer to rather work on your own?	1	2	3	4	5
7	Did you have to work hard to execute this task?	1	2	3	4	5
8	This method has helped me to learn how to solve problems.	1	2	3	4	5

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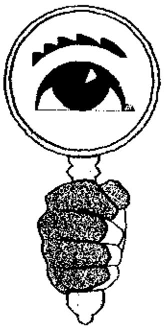
Appendix 5

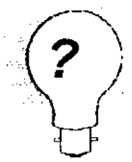
Meta-learning checklist and format of the resource kit

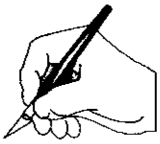
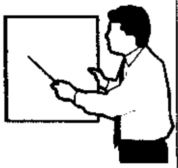
RESEARCH CHECK LIST

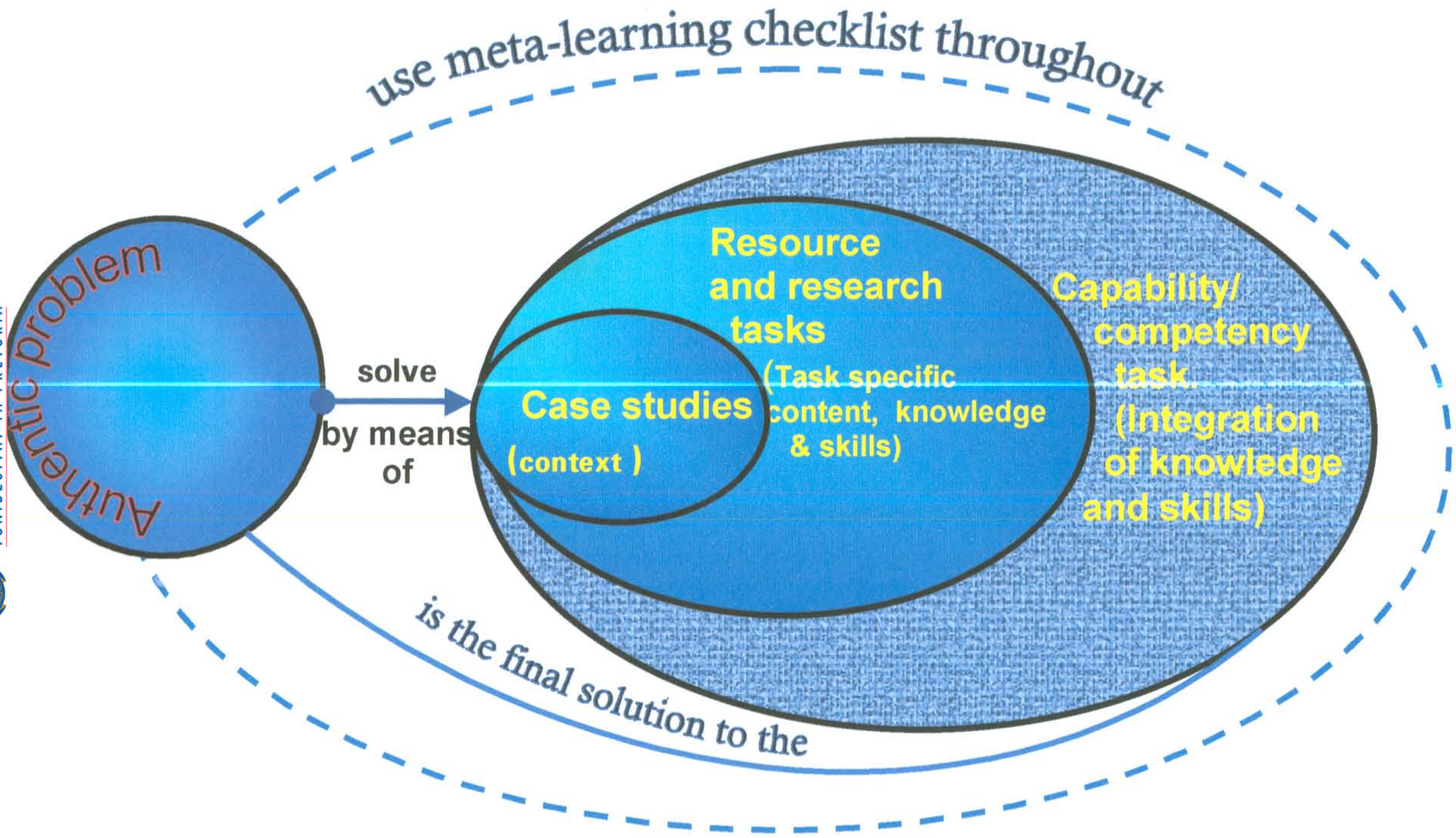
Animation	RESEARCH ACTIVITIES	❖ I have considered this issue ✓ ❖ Needs more consideration ❖ Comments
	Chapter 1: **Chapter 2: PHASE 1: THE PLANNING PHASE**	
	1. We have to solve a problem. Where should we start?	
	2. We first have to understand the problem! How? Should we read it again? Shall we first think about it individually? Shall we discuss it with one another? Do we need to do more reading?	
	3. We need to understand <u>all</u> the requirements and their implications before we can adhere to all of them.	
	4. We will need resources. Where shall we find and access our resources?	

 	5. Are the resources sufficient, relevant and reliable? Do we need to find more/other resources? Like what? ◆ Use the prior knowledge and experiences of each team member as a resource. Some of us might know quite a lot about energy, alternative resources and laws of energy conservation and transfer motion. ◆ Is the information in the information center in terms of books, articles, newspapers? ◆ Is the information in the information center in terms of the internet? ◆ Is the information in terms of video's and TV? ◆ Shall we phone environmentalists, enginees or anyone else who will be able to . ◆ Shall we phone environmentalists, engineers or anyone else who will be able to give advise? Shall we design and execute with prelimenary experiments to gather information.	
 	6. How are we going to organise and manage our team to get to the best solution?! ◆ Will each individual be working on his/her own? ◆ Will all the team members work simultaneously on all the aspects of this problem? ◆ Will each team member first work individually <u>before</u> we get together to brainstorm solutions and designs? ◆ Will each team member research and design their own prototypes and then select the best design and work on that as a team.	•

	7. What other planning still needs to be put in place before we can start writing, designing and building our prototype ❖ How and who will manage the technical and language editing of our research and design portfolio? ❖ How and who will manage the presentation to the stakeholders?	
	8. Is each team member enthusiastic about the team's suggested solution?	
	9. Is the suggested solution/or design the <u>best</u> and competitive?	
	10. Are all team members satisfied that the suggested solution is the best one? If not, what else do we need to do?	
	PHASE 2: LET'S START WITH THE EXECUTION OF THE TASK AND SOLUTION OF THE PROBLEM	
	2.1 PHASE 3: MONITOR THE EXECUTION OF THE PLAN	
	While we are busy with the problem solution we need to consistently monitor our progress, quality of work time, and other available resources.	

	11. ◆ Are we still enjoying what we are doing? ◆ Are we still focusing or are we being side tracked?	
	12. ◆ Is our suggested solution and design still the best option? ◆ If not, what and how do we need to adjust it?	
	1. Are we keeping to our time schedule? ◆ If not, why are we behind schedule? ◆ What do we need to do to catch up?	
	14. What else needs to be monitored?	
	2.2 PHASE 4: WE NEED TO ASSESS AND EVALUATE OURSELVES, OUR INPUTS AND OUTPUTS	
	Finally, the last phase! As a team, we have gone through a **process** to get to our final solution, design and technological prototype. Before we can attempt to present or sell this to the world outside, we have to evaluate it **critically** and **objectively**.	
	15. Have we solved the problem?	

	16. Does our solution adhere to the initial requirements? If not, how should we address this fact?	
	17. Is our research and design portfolio complete? ◆ Is it technically and language edited? ◆ Does it display a professional quality?	
	18. Are we satisfied with the prototype? If I am an outside roleplayer, will I invest in this design and prototype for future development?	
	19. The presentation: ◆ How will we divide up for the presentation? ◆ How am I going to prepare for the section which I need to present? ◆ Am I going to make a slide show presentation? ◆ Am I going to make use of transparencies? ◆ Am I going to make use of video clips? ◆ Am I going to present my research data in table and/or diagram/form, format? ◆ Will I be able to answer the questions during the press conference?	
	20. Are we proud of our work?	
	21. Am I proud of myself?	
	22. I need to assess the project.	


use meta-learning checklist throughout
Authentic problem
solve
by means of
Case studies
(context)
Resource and research tasks
(Task specific content, knowledge & skills)
Capability/ competency task
(Integration of knowledge and skills)
is the final solution to the

Appendix 6

Perceptions on technology, technology education and appropriate methodologies to facilitate learning in technology education of pre-service teachers prior to their PBL training

Vrae /Questions:

1. **Wat is tegnologie? Verduidelik./*What is technology? Explain.***
2. **Wat is tegnologie-onderwys? Verrduidelik./*What is technology education? Explain.***
3. **Is daar 'n verskil tussen tegnologie en Natuurwetenskap?/*Is there a difference between technology and natural physical science?***
4. **Wat is die verskil?/*What is the difference?***
5. **Wat is die effektiefste manier waarop tegnologie onderrig kan word?/*What is the most effective approach of methodology which may be used to teach technology?***
6. **Wat is die stappe van die tegnologiese proses?/*What are the phases in the technology process?***
7. **Dink jy Suid Afrikaanse onderwys is in die posisie om 'n vak tegnologie aan te bied?/*Do you think South African education is positioned to introduce technology as a new subject?***

PRE-SERVICE TEACHER A:

1. Technology is new developments on various terrains which can make life easier. Eg. a sewing machine which helps to safe time and enhance the quality of the final product. It differs from person to person. In Sa the new technologies are not the same as in the USA.
2. Technology education, according to me, is where learners are guided and exposed to developments which can make certain tasks easier and which may be used eg. computer software.
3. Yes, there is a difference.
4. They go hand in hand. Physical science facts/principles are fixed but technology may be developed by using the facts/principles.
5. Through practical application. It does not help to show learners a picture of a sewing machine. They must use it or else it is not technology for them. Learners must also be allowed to discover for themselves with the technology to their disposal.
6. Use equipment to make the best product in the shortest time.
7. Every school will be different and must decide for themselves what they want to offer in the community as technology.

PRE-SERVICE TEACHER B:

1. Technology involves new discoveries and apparatus which makes everyday life easier (comfortable). These apparatus does not necessarily have to be technical/electronical.
2. Where learners get the opportunity (with appropriate guidance) to discover new things and to resolve problems which they encounter and to make them easier. Furthermore, learners can develop the necessary technical skills (and discover knowledge).
3. Yes, somewhat.
4. The two are not exactly the same, but bot have aspects of each in them. Where the two are most similar, is that one has to be inquisitive in the you constantly look for problems and try to solve them. "Need to know" in part of both. It is this attitude which is of utmost importance in technology.
5. Technology cannot be taught – you cannot just use the old paradigm of transfer to learners. You as a teacher have to cultivate the attitude of being inquisitive and innovative and create a learning environment. You can also equip learners with the necessary knowledge (and practical skills) to solve problems effective and creative – through new technological discoveries.
6. No idea. Maybe something like
   - See problem/shortcoming (discover problem after an investigation);
   - Find solutions (few hypothesis);
   - Select the best option (test hypothesis – select the best);

- Evaluate and reflect;
- Back to first step.

7. Not 100% equipped at this moment; because teachers (facilitators are not well trained enough to implement it effectively. The shortage of facilities, media, etc is not (suppose) to be a limiting factor – the subject is about solving the problem!

PRE-SERVICE TEACHER C:

1. It is the progression and development of resources and aids for humans. Technologies used by man is improved constantly – strive for zero defect.
2. Teachers teach learners about the latest technologies. Learners learn about technology and try to make their own developments (improve on existing technology).
3. Yes.
4. As science is currently presented, it comprise the learning of basic scientific concepts (Biological, Physical, Chemical, Mathematical). Technology focuses on the use possibilities (and the production) of these basic concepts.
5. Practical investigations and experiments by learners, but especially research by the learners themselves about the latest technological developments. Teaching has to be done by someone who knows enough and who is interested in the subject, else it would only be another dead subject.
6. I don't really know. Maybe it is like the scientific process of hypothesising, experimenting (repeat and accurate). Verify or reject the hypothesis, formulate a theory and finally produce a final product.
7. SA has a lot of potential, but not the necessary funds to keep up with first world countries. If it's not about money, Yes.

PRE-SERVICE TEACHER D:

1. Personally I don't believe that there is one person who can give an exact definition of technology. For me the word has a very broad meaning. I tend to think about computers and all the modern electronic equipment. However, I know that technology is much more than that.

2. Technology education according to me is very practical and true to every day life. It is about teaching them the processes which should be used to discover equipment for themselves and to improve on it.

3. Yes.

4. Science do the research to develop basic knowledge which engineers then can use to design, develop, produce and improve ideas.

5. According to me the most effective method would be to use real life problems and to present it very practically.

6. No idea.

7. I do not think anyone knows in what position SA is in terms of anything. I do however feel that it should be made possible to present technology as a subject.

PRE-SERVICE TEACHER E:

1. It is the development of equipment, resources and techniques which have to fulfill certain functions in society. It also includes products which makes everyday life easier and quicker so that we can be more productive at a cheaper rate.
2. It is the facilitation of skills which learners have to learn to apply in technology, as well as developing a thinking process where learners have to think beyond the here, now and known.
3. There is a small difference between physical science, technology and engineering.
4. Physical science deals more with theoretical aspects, engineering deals with the practical aspects and technology is a combination of the two fields.
5. The most effective way is to give them practical exposure. The more learners are kept abreast of the latest technologies and the more they actually work with it, the more effective they can be in improvising and contributing.
6. I don't know, maybe it is: identify a problem, find a solution, test, evaluate and implement – it actually is the same steps which engineers use.
7. These days SA can also present technology. Earlier year not , because we were underdeveloped.

PRE-SERVICE TEACHER F:

1. It is the adding of value to ideas.
2. It can have a double meaning. On the one hand it is the teaching about new technology. On the other it is about teaching issues related to a specific area, such as food technology.
3. Yes and no.
4. Both strive for prosperity. In science some theories cannot be improved on such as Einstein's theory. Technology is much more modern than science.
5. Technology will be taught effectively if there are enough equipment (computers!) for each learner.
6. I do not know which process to follow.
7. No, there is not even enough money to buy textbooks. In private schools something like this will work because they have funds available.

Appendix 7

Semi-structured interviews with pre-service teachers after their PBL training and classroom interventions: Transcripts

RESPONDENT NUMBER: Pre-service-teacher 001

Name of School: A

10 September 1998

Question 1:
How did you experience the problem-based approach in your training?

Sjoe- it was really different to what we were used to – but subject didactics is supposed to be more practical than our formal lectures. And it was really practical orientated. In none of the other classes we really had an idea what this new type of teaching was, we were told about it but we never really understood what we had to do if we stand infront of a class. (Tell me more about the problem-based approach which was used to train you in the 6 months). At first we didn't know that you used this type of method called problem-based teaching – you only told us this name later. All I know is that we were given many problems, some shorter and some longer ones which finally helped us to understand tech education. It kept us very busy because we couldn't find all the answers of what we were suppose to do in textbooks – because you didn't; prescribe any.

Question 2:

2.1 How did the learners experience the problem-based approach? Think of your classroom experiences.

2.2 Tell me more about HOW you facilitated the PBL.

2.1 In the beginning they were very enthusiastic because it was something new and different. After 3 weeks the enthusiasm of some faded, because they realised it was not just a play-play task. The time came close to demonstrate their energy devices. They didn't' realise that it was such hard work to do their own research and to plan the whole thing on their own. I think if a facilitator doesn't know what he is doing it can become chaos in a class of 20 and bigger.

2.2 The learning opportunity design was already done and what to do when learners reach a certain stage was decided before the time by all the students. The control class was taught the way we discussed before the time. In the other class I moved in between the different group all the time. Actually all I did was to encourage and motivate them. Although they asked me questions when I reached a group, I didn't really give them any hints, because the idea is that they do the work, isn't it? Sometimes I got the idea that some individuals were very frustrated with this method.

How would you explain to a fellow student or parent what technology education is.

It is to use or apply science knowledge to solve problems which, when solved can make life easier on different levels.

Question 4:
Technology education was facilitated within an OBE framework. What expressions of OBE have you gained through this training and practice experience?
I don't think that you can teach technology in another way than this way. I will definitely

use it to teach other subjects as well next year.

Interviewer: Explain more

Student: Finding solutions to problems, is something that cannot be given – the individual has to look for it by doing thorough research. Doing your own research under the guidance of a facilitator is OBE methodology, isn't it?

RESPONDENT NUMBER: Pre-service teacher 003

Name of School: B

9 September 1998

Question 1:
How did you experience the problem-based approach in your training?

Student: Mm – I think at first I found it a loose approach. I am one of those people who like structure.
Interviewer: Briefly explain what you mean by structure?
Student: I guess I like well organized presentations. I must say that I use the word presentation rather than lecture because it fits better into this new stuff. We also don't prepare "lesson" anymore but learning opportunities. I (Yes) tell met more about your training experience. I dind't know anything about technology – at least I understand technology better now and that technology is all about solving some needs of society and that is why you gave us all the …….. I mean problems to solve. That is how it is going to be in a technology, or even a science classroom. I don't think that all subjects can be presented like this, but it will work in a subject didactics class.

Question 2:
2.1 How did the learners experience the problem-based approach? Think of your classroom experiences.
2.2 Tell me more about HOW you facilitated the PBL.

2.1 Some of them thought it was playtime because they didn't have formal lessons. For some of them the idea of doing the whole task as a group was the greatest attraction of the whole thing. Normally they work in groups when they do practical work, only – but then they don't' devide the work up so that each is responsible for something. To make sure that teach learner experienced the whole process, I reminded them frequently to use their checklists. They seemed to forget that.

2.2 It took a lot of my energy to work in this way. All the learners wanted your attention at the same time. "If a cooperative group show you their progress it was difficult for me to determine how much feedback to give them. My feedback was of the nature: "That's OK", It's great" "You need to rethink this", "You need to add something and so on"

Question 3:
How would you explain to a fellow student or parent what technology education is.

To teach children to identify problems, to look for solutions and to evaluate it. Technology is need-driven.

Question 4:
Technology education was facilitated within an OBE framework. What expressions of OBE have you gained through this training and practice experience?
Student: I think this training in technology education has given me a good idea of how to teach on a OBE way.
Interviewer: What ideas did you get?
Student:
- How to prepare and design problems.
- How to look for resources for a resource kit and how to plan cooperative groupwork.

Name of School: C

9 September 1998

Question 1:
How did you experience the problem-based approach in your training?

I feel that this training was very practically orientated and relevant and it is this fact which made the course successful. I have personally grown and I believe so have my fellow students. By means of cooperative learning we could access one another on a continuous basis, and we got valuable ideas and information from one another. At the beginning of the year I couldn't' think creatively at all because it was never necessary to be creative. Your approach has challenged me to develop my creative thinking to such an extend that I can think diverse about problems and solutions. For the problems which we had to do first before one went to the schools, I actually landed up in the Department of Biochemistry. I had some valuable discussions with lecturers there which broadened my horizon. Finally I think this approach will not only work for technology, but for many other subjects as well.

Question 2:
2.1 How did the learners experience the problem-based approach? Think of your classroom experiences.
2.2 Tell me more about HOW you facilitated the PBL.
Learners were exited about the whole project after they were presented with the problem. They have asked to work in groups themselves and the class was divided in 4 groups with 5-7 learners per group. Two of the groups have done good research. They have divided the research amongst themselves and each member had to report back to the group on their part of the research.
Interviewer: Did the themselves decide to divide the research work between one another?
Student: No – I told them (facilitated rather) to do that, because I wanted them to work cooperatively – there had to be positive independence. The other 2 groups didn't do much about their research and wanted to know from me certain answers. Some of the learners said that they have really learnt something and that it was fun. Some said it was a waste of time because they have fell behind with their regular work.

Question 3:
How would you explain to a fellow student or parent what technology education is.

When we were asked our perceptions of technology education earlier I said that it is the facilitation of skills which have to mastered to apply and use certain technology, and that it also develops a thinking process where learners have to think beyond the here and now and the familiar. With my new insights into technology education I don't think I was too far out. I still think it is not only about products, but about a thinking process.

Question 4:
Technology education was facilitated within an OBE framework. What expressions of OBE have you gained through this training and practice experience?

Well, in technology education, like in science education learners have to discover and explore on their own. In technology education they have to design and make their own ideas —they are not given a design to just copy and make. It seems to me that is what OBE is all about in practice. These learners had to analyse their own information from the kit and other books and the internet. The other class received notes and lessons within all the information. They were given the experiment and exactly how to do it. They actually only had to follow the prescribed instructions. That's the difference between OBE and the other method.

RESPONDENT NUMBER: Pre-service teachers 004 and 005

Name of School: D

10 September 1998

Question 1:
How did you experience the problem-based approach in your training?
A: There were so many new things that we actually had to learn. We did not really know what technology was. Everybody had their own ideas of this subject because it is so wide.
B: Sorry, I want to add that on top of a new subject, we had to do it in an OBE way.
Interviewer: Did the PBL approach help in any way?
B: Well yeas, technology and OBE is all about applying your knowledge and by giving us problems, we learn how to apply our own knowledge.
A: I don't think we know enough about technology education but at least we know something about the methodology of teaching it.
Interviewer: What is that methodology?
A: Well that learners must do their own research and set-up their own experiments if they want to investigate something.
B: Yes – but you can't really just leave them, some of them wont investigate anything. It will help you if you know the learners and then you put them in a group which will pull them along. It's the same with you R, if you weren't in my group you would do anything.
B, Ag sies man.
A: Joke.
B: Well I am glad that you divided us in groups to do the tasks.
Interviewer: Why?
B: It makes a big task like this much easier and we know all the benefits of groupwork.
What are they?
A: We brainstorm – the more ideas, the better we share the research work amongst us, and we learn how to work with fellow students. That's why R and I decided to do the project together at High School A.

Question 2:
2.1 How did the learners experience the problem-based approach? Think of your classroom experiences.
HOW you facilitated the PBL.

B: Some of the very clever learners felt that the project could have been done in 3 weeks. They forget however that the LEMOSS and other tests took time which was not teaching time. Some said that they also wanted the notes with the other class received, but P explained in nicely to them.
A: Yes, I told them that we didn't want to teach them facts only, but also the process of working through the facts to be able to do something useful with the facts. They understood this ideas quite well.I must say that I am glad that we were two.students.
Interviewer: Why?
I think if a facilitator doesn't know what he is doing it can be chaos in a big class.
Interviewer: Why?
A: There is a lot of noise and the more existed they become the louder they speak. They also move around a lot.
B: For the rest "Some of the groups were fine, but I was really worried about some of the group ....they loose interest if they really don't see their way out. Although we encourage them not to loose heart. I know that I am a facilitator who is not supposed to transfer, sometimes I felt like doing it.
A: I agree with B. I think we experience in working with cooperative groups. The easy way out will be just to tell them what they need so that they could carry on.

Question 3:
How would you explain to a fellow student or parent what technology education is.

A: It teaches a pupil to think problem-orientated. He must comprehend the problem, find a solution, design and make a product ad evaluate it. In the process numerous skills are being learnt through the "resource tasks" which help him to develop into a useful person.
Interviewer: Would you like to give an explanation B?
B: No, I can't improve on A's.

Question 4:
Technology education was facilitated within an OBE framework. What expressions of OBE have you gained through this training and practice experience?

B: I think that I understand now that outcomes are more than facts and textbook content. In technology one of the outcomes is the problem-solving process which learners need everyday in their lives. Outcomes can also be the skills which I has referred to in his explanation of technology.
A: And I think we showed the science teachers in this school a good example of OBE methods.
Interviewer: What are the OBE methods.
A: No lessons, where teachers transfer information but problems and cooperative work where learners look for their own info.

RESPONDENT NUMBER: Pre-service teacher 002

Name of School: E

9 September 1998

Question 1:
How did you experience the problem-based approach in your training?

I like new things. I liked it very much. Yes this was the one subject in which I have learnt the most in the whole year. Except for learning how to design lesson presentations, I also learnt a lot about the subject which I am to teach as well. All the extra effort I had to put in looking for relevant problem settings forced me to look beyond past textbooks. We had the opportunity to look and use everything in the subject didactics, but it also had relevance for our own classrooms next year. The evaluation process were excellent. I think the small theory tests were of utmost importance to refresh our knowledge. The exam evaluation was also very relevant. It tests that which we are supposed to demonstrate in practices

- design and setup ....
- skills
- evaluation skills
- how to apply outcomes-based methodologies

Question 2:
2.1 How did the learners experience the problem-based approach? Think of your classroom experiences.
2.2 Tell me more about HOW you facilitated the PBL.

2.1 Personally I think that the learners in this school have gained very much from this whole project. The problem forced them to use different resources, apart from the kit they received. I know that we had to do the same things in the different schools, but I decided to arrange a field-trip to a coal mine where they could see energy and technology in action. My husband is an engineer there so it was quite easy to organise it. I thought if other schools could use internet as an extra resource, I can use the coalmine experience as an extra resource. The principal liked the idea so much that he said that he would appreciate it if the whole grade 10 science group could go. I got so much support from the principal and the 2 science teachers. It think everybody enjoyed technology with its new approach. When the learners had to build their biogasmaker – I had to stop the parents from doing it. One farther wanted to build a real big thing for his daughters group.

2.2 I gave them a lot of motivation, and I believe if you show your enthusiasm they get it from you.

Question 3:
How would you explain to a fellow student or parent what technology education is.

Student: We all know the definition now, must I give the definition.
Interviewer: Explain to that enthusiastic father what technology education is.
Student: Ok. We use technology education to teach your child to (mmm....) think out different solutions and to select design and make the best solution. Technology is not only making things, but to do proper research before you start making it.

Question 4:
Technology education was facilitated within an OBE framework. What expressions of OBE have you gained through this training and practice experience?

I don't' think you can teach technology in another way, than this way. I will definitely use it to teach other subjects as well next year. If you give them problems and research to do, that is OBE. OBE is about taking them out of the classroom away from one textbook to the real life outside – like I did with the coalmine fieldtrip.

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Appendix 8

The learning and motivation strategy questionnaire in science (LEMOSS)

LEMOSS

QUESTIONNAIRE FOR LEARNING

AND

MOTIVATION STRATEGIES

IN NATURAL SCIENCES

N J S BASSON, L F GEER, R GOOSEN

UNIVERSITY OF PRETORIA

INSTRUCTIONS

This is a questionnaire to help you to become a better learner in science. To be able to do this please answer all the questions **VERY HONESTLY**. On every question you must **CHOOSE ONE** of the following answers:

**N = NEVER
**S = SOMETIMES
**F = FREQUENT
**G = GENALLY
**A = ALWAYS

YOU MUST ANSWER ALL THE QUESTIONS

1. When trying to solve a problem in Science I usually do not know where to start and it seems that I can not use anything that I know.

2. While writing Science tests I realize I emphasized the wrong parts and did not realize that the work, that is asked about, was that important.

3. Although I know Science I always have difficulty with solving problems.

4. I do not always understand the essence of some questions in Science examination papers.

5. I always try to find connections between different concepts I study in Science.

6. I always try to investigate laws and definitions again in practice by doing experiments to obtain a clear understanding of the phenomenon.

7. When hearing or reading an explanation or conclusion in Science I look for alternatives with the same meaning.

8. When studying new concepts in Science I always try to relate them to concepts I already know.

9. I always try to find connections between new information that I come across in Science, and my existing knowledge.

10. I use simple diagrams and tables to summarise Science.

11. I use diagrams and tables in Science to organize the contents and form a complete image of the work.

12. I use the headings of chapters in my textbook to identify important aspects of the Science I am studying.

13. While studying Science I try to ascertain which concepts I do not understand.

14. When reading Science I try to follow the logical course of thought and facts by rereading parts of the contents.

15. When I do not understand what I study anymore I start again from the beginning in order to try to understand.

16. I think it is useful for me to study Science.

17. I think I would use the Science I studied in the classroom some day in my profession.

18. I know I can perform very well in Science if only I pay attention in class, do my homework frequently and have enough time to study.

19. If I try hard enough I will understand Science.

20. I would like to perform better in school than most of the other pupils if possible.

21. The greatest satisfaction I get from school work is to achieve good marks.

22. Almost after each test it is clear that I had to cram the information into my head and I only realize later how the information should have been applied.

23. It seems that if I overlook the main points while studying Science, but get entangled in the smaller detail.

24. While studying Science I am convinced that I understand it but when the teacher explains the memorandum, I discover that I did not understand it at all in the first place.

25. During tests and examinations in Science the teacher combines concepts in a single question, that I would never relate to one another.

26. When reading Science, I look for reasons why the work was done in the first place and how it can be applied in problem solving, because it gives me a clue of the logical course of the contents.

27. Before I study new laws, definitions or rules in Science, I try to ascertain which of the concepts they are compiled of, I already know.

28. I memorise new definitions and laws by imagining certain situations that contain the definitions and laws.

29. I try to relate new information in Science to my own experiences gained in the laboratory or in nature.

30. I find it important to know in which cases new information can be applied and when not.

31. I memorise key words to remember important concepts in Science.

32. I first scan through Science briefly in order to obtain the whole image of how it is structured, before I read it thoroughly.

33. While studying Science I think of possible questions that can be asked in the examination.

34. While working through Science I frequently stop to go through the reasoning in my mind.

Appendix 9

Specific outcomes, assessment criteria and range statements for selected outcomes in the natural science Learning Area

Specific Outcome 2	DEMONSTRATE AN UNDERSTANDING OF CONCEPTS AND PRINCIPLES, AND ACQUIRED KNOWLEDGE IN THE NATURAL SCIENCES

This specific outcome is central to the Learning Area of the Natural Sciences. Its concern is to make learners familiar with the developing array of knowledge, concepts and principles within the Natural Sciences. However, the demonstration of a learner's understanding of these concepts and principles should be seen as happening most meaningfully in those specific contexts which involve learners' activities. Theoretical knowledge is necessary but not sufficient. The ability to apply knowledge is essential. The range of learners' actions to attain this outcome is therefore related to the other specific outcomes. These other outcomes relate the Natural Sciences and its array of knowledge, concepts and principles to practical daily-life situations and issues. It is through the ability to use, extend and apply knowledge that a learner can be said to "understand" concepts and principles in the Natural Sciences.

SENIOR PHASE

Assessment Criteria	**Range Statement:**
Learners show work in which:	*In developing their work learners:*
◆ Acquired scientific knowledge, concepts and principles are used to inform actions.	Acquire and develop knowledge and an understanding of scientific concepts and principles – including laws and formulae – (See also S.O. 1, 3, 4, 5, 6 and 8 which concern activities such as investigating, problem solving and decision making in everyday contexts). Learners will develop their understanding of concepts and principles in each of the four Themes, separately or in combination: Key concepts and principles, laws and formulae within the four themes are understood applied in investigating, problem solving and decision making in contexts from either the learners' direct environment, or from environments not directly falling within the learners' day-to-day interests but which are of general importance to learners. Energy & Change: key concepts such as: force, heat, electricity, velocity, homeostasis… .

Specific Outcome 3	**APPLY SCIENTIFIC KNOWLEDGE AND SKILLS TO PROBLEMS IN INNOVATIVE WAYS**

This specific outcome concerns the development of the capacity of learners to work on problems using scientific knowledge and skills. The outcome is related to specific outcomes 1 and 5. The emphasis, however, in specific outcome 3 is the solving of problems. In the solving of problems, investigations have to be done and decisions also have to be made. It is therefore necessary to consider specific outcome 3 in connection with the assessment criteria and range statements of specific outcomes 1 and 5.

SENIOR PHASE

Assessment Criteria	**Range Statement:**
Learners show work in which: Problems are identified. Relevant information is gathered. Relevant scientific knowledge is selected. Relevant scientific skills are selected. The problem is re-evaluated. Innovative options are generated. Decisions are made. Possible plan of action is communicated.	*In developing their work learners:* Access a wide variety of sources to gather information on problems, scientific knowledge and skills through activities such as practical investigations, using various media and interview-techniques Use scientific skills for investigations (see also S.O. 1, Senior Phase). Use individual and group work strategies to make a detailed plan of action, outlining responsibilities, priorities and an ordered step-wise plan of work which could include experiments. Re-evaluate the problem through group or class presentations, discussions and debates, possibly developing a new perspective in view of all of the information gathered. Brainstorm to generate and debate innovative options and solutions to the problem. Decide on the best option, clearly justifying the choice on the basis of ordered and clearly presented scientific evidence. Communicate conclusions and recommendations in a variety of ways, each of which show logical build-up, coherency and consistency in methods and reasoning. Design and build – where appropriate – a usable device or technology that addresses the problem, or propose a plan of action. Learners will be involved in problem solving activities in each of the four Themes, separately or in combination:: The problems identified could be some general (e.g. provincial or national) importance, and its solution or way of addressing it could have an impact both within and outside the learners' direct environment.

Specific Outcome 5	USE SCIENTIFIC KNOWLEDGE AND SKILLS TO SUPPORT RESPONSIBLE DECISION MAKING.

This specific outcome concerns the development – in learners – of the capacity for making informed and responsible decisions, recognizing the use of scientific knowledge in the process of making decisions, and seeing that making decisions has consequences. The outcome is related to other specific outcomes, most notably numbers 1, 3 and 4. In these outcomes high-light aspects related to decision making – such as investigating and problem solving. Specific outcome 5 emphasizes decision making as an important part of using scientific knowledge and skills in everyday life. Important is that learners develop an understanding of how decisions are reached; how information gathering is important; and that scientific knowledge and skills must play a role throughout the process.

SENIOR PHASE

Assessment Criteria	**Range Statement:**
Learners show work in which: Issues are identified. Scientific information relevant to the issues is gathered. Information is prepared for the decision making process. Non-scientific issues are acknowledged. Alternatives are considered. Reasons for decisions are communicated.	*In developing their work learners:* Brainstorm, discuss and debate – using a wide variety of information sources – to identify issues. Access scientific information related to the issues from sources such as textbooks, libraries, television, interviews, pamphlets. Work individually or in a group to identify the critical and essential viewpoints, attitudes and values related to the issue. Reflect and argue how scientific input and other input generate action plans or alternatives. Communicate – in a variety of ways – decisions and possible consequences, relating viewpoints and scientific input in a consistent way. Learners will be involved in decision making in each of the four Themes, separately or in combination: Decision making will take place in a context that might relate to learners' direct experience or might relate to issues that also reflect a more general – but for the learners relevant – national or international concern.