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 own. 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**

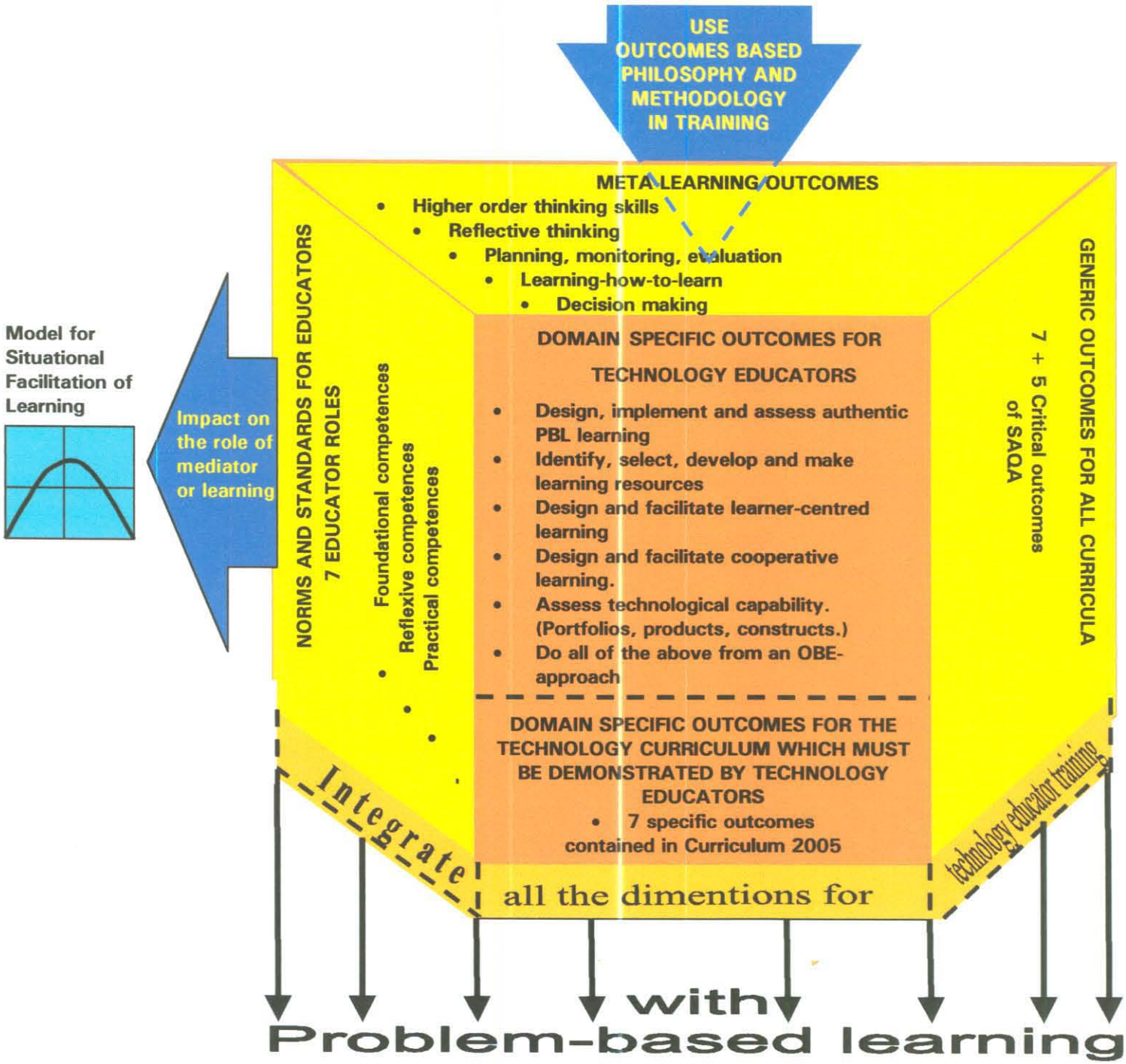
The assessment table confirms that the OBE-PBL model has a multiplicity of dimensions and variables that influence the suitability and effectiveness of the OBE-PBL model for pre-service training of teachers for and outcomes-based technology curriculum. Some of the criteria have been exceeded, some met 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 OBE model



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

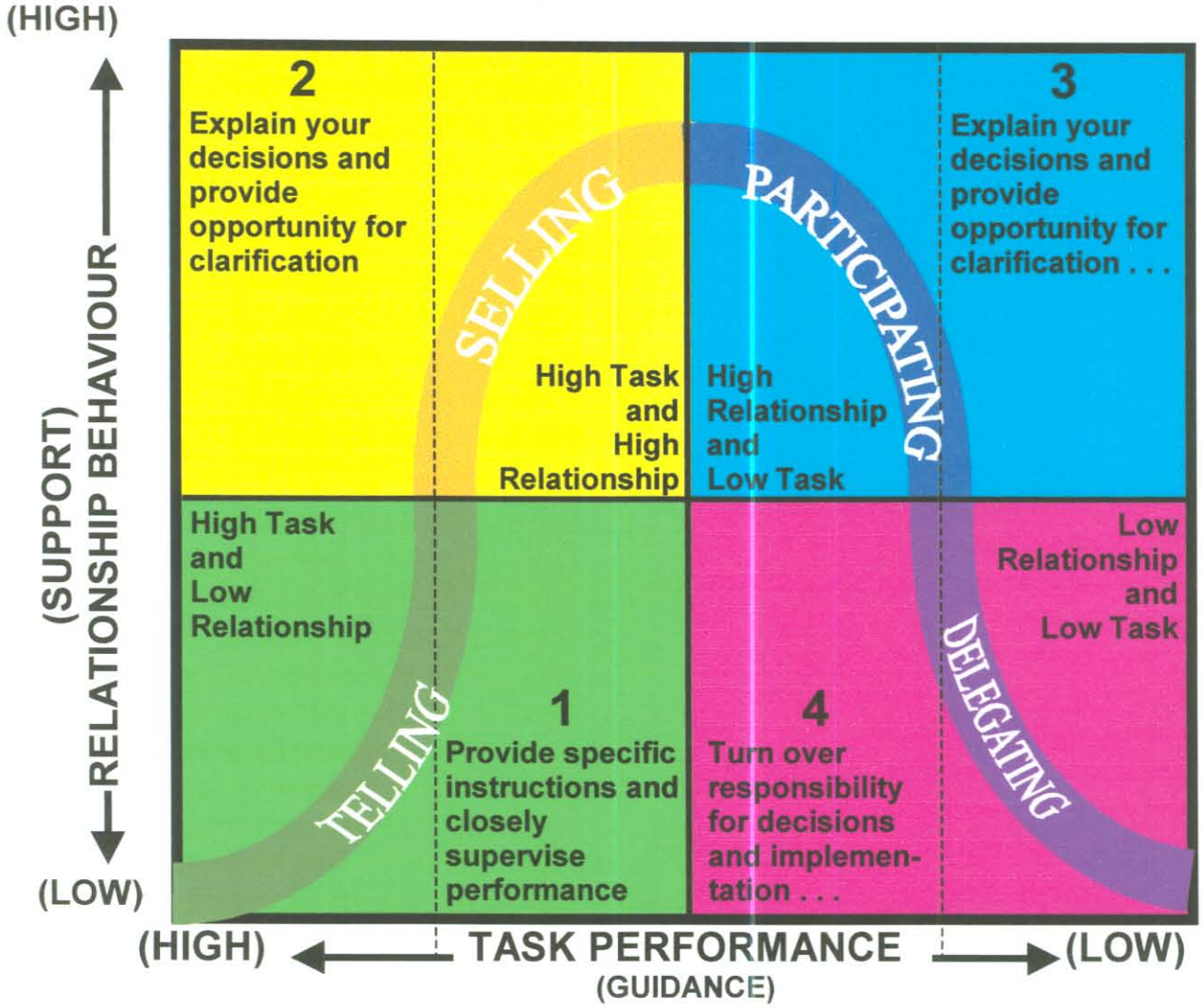
task behaviour, but also relationship behaviour. When learners have reached a M4 level of maturity, they are able in their task performance, but also display psychological maturity. Socio-emotional support and task direction are no longer necessary and the facilitator can adopt a style of delegation, 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).

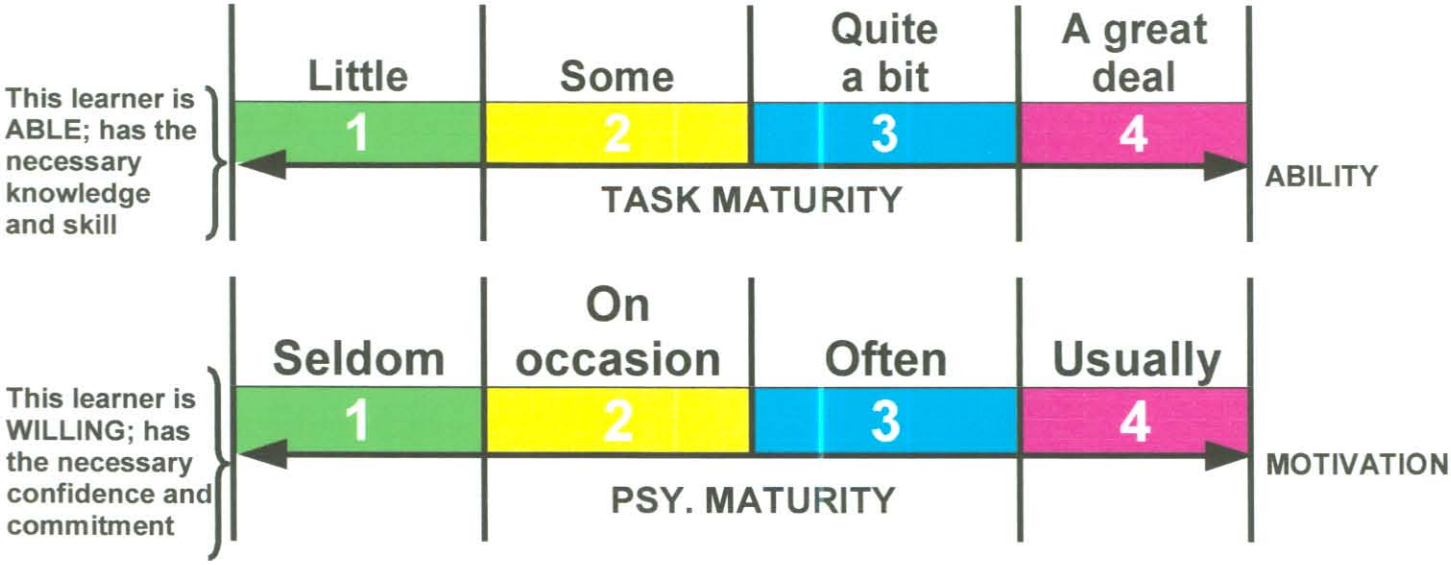
The aforementioned explanation about the Situational Learning Facilitation Model can be summarised as follows before the model is presented:

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-modern 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.