CHAPTER 4

RESEARCH DESIGN, METHODOLOGY AND INTERVENTIONS

4.1 Introduction

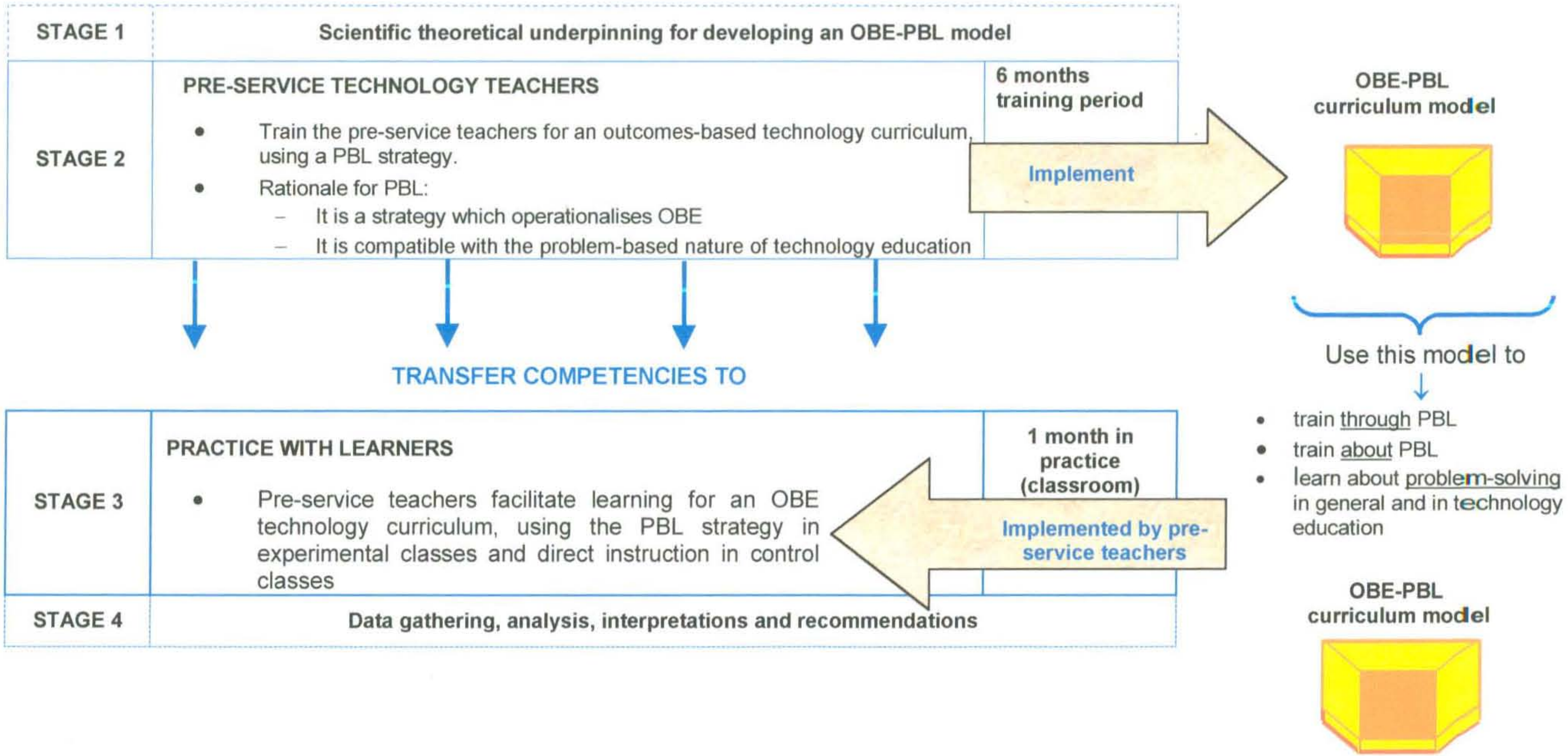
A researcher needs to give full account of the scientific methods, techniques and instruments which were employed to obtain valid knowledge in the search to answer the critical research questions (Landman, 1985:4, Bogdan & Bilken, 1992:58 and Schurink, 1998:241-242). This chapter will elaborate on the 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 admini-stration	Education Communica-tion	Teaching practice	Human movement sciences
5	11:30 – 12:30	*	School organisation and admini-stration	Educational Technology	Religious studies	School organisation and admini-stration
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

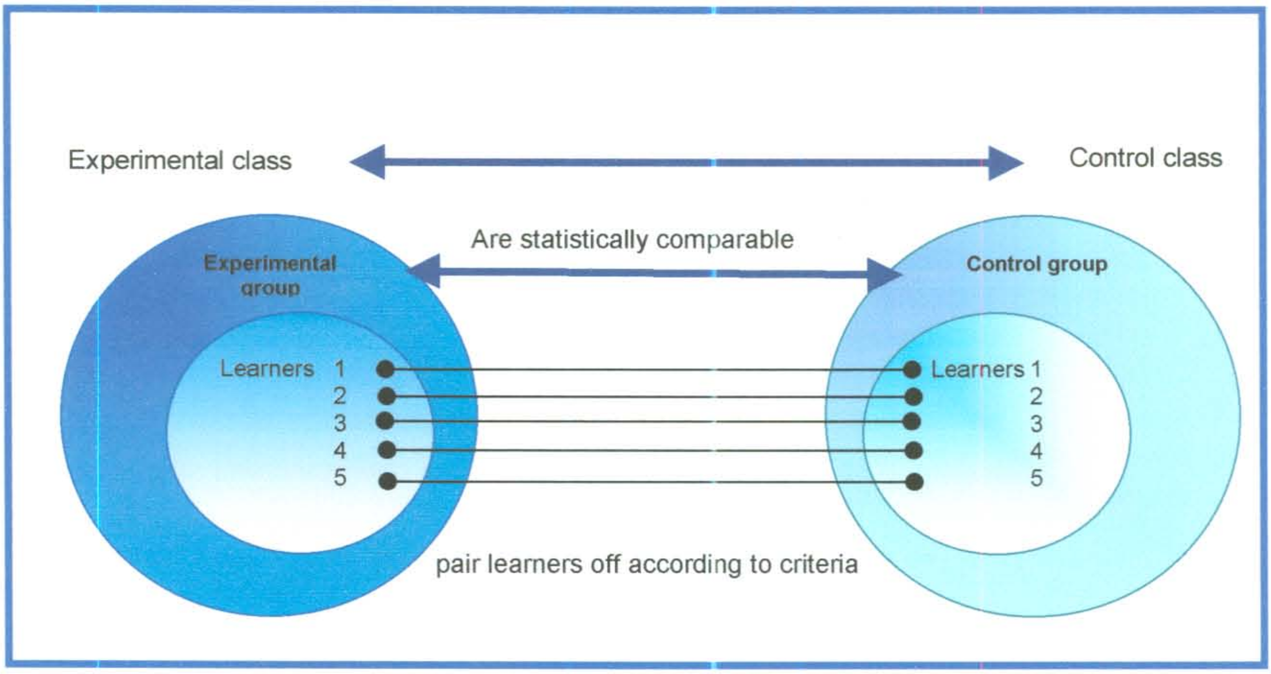
This outcome called for a strategy which could be used to identify within each of the classes which learners could be paired off to form two groups which would be statistically comparable. In other words, two groups within the experimental and control classes in each school had to be identified which 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):

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.

MONTH 2	
Problem focus for the different co-operative groups:	**Co-operative group 1 and 2:** PBL as curriculum and teaching strategy in OBE.
	Co-operative group 3 and 4: Problem-solving strategies for PBL
	All the co-operative groups: Analysing the PBL curriculum of the Medical School at Pretoria University.
	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

	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.

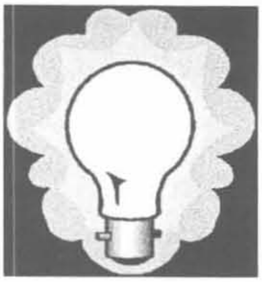
The specific outcomes from the technology and science Learning Areas, which had to be demonstrated by the learners after the interventions, are presented below. The associated assessment criteria and range statements for the specific outcomes from the natural science Learning Area will be included as Appendix 9. The same information for the technology Learning Area is available in Appendix 3.

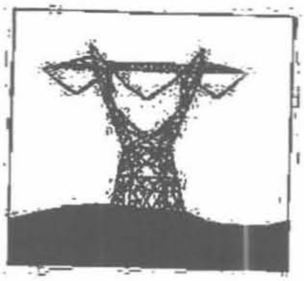
ENVISAGED TECHNOLOGY AND SCIENCE OUTCOMES
LEARNING AREA: TECHNOLOGY
• **Specific Outcome 1** Understand and apply the technological process to solve problems and to satisfy needs and wants. • **Specific Outcome 2** Apply a range of technological knowledge and skills ethically and responsibly. • **Specific 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.