CHAPTER 5

ANALYSIS AND PRESENTATION OF QUANTITATIVE AND QUALITATIVE RESULTS

5.1 Introduction

The previous chapter elaborated on the research methodology, interventions, instruments used for obtaining data, as well as the data sources. To determine the implementation success of the OBE-PBL model as a training strategy of pre-service teachers for an outcomes-based technology curriculum, results are necessary to answer the research questions. The results which were obtained from the variety of data sources will be discussed in this chapter. One of the data sources was the experimental group of learners who were exposed to PBL by the pre-service teachers. The other group was the control group who were exposed to direct instruction methods. These data sets were obtained by means of empirical methods. The other data source was the pre-service teachers themselves who were trained through the PBL strategy and who had to facilitate learning through the PBL strategy. This particular data set was qualitative in nature. The quantitative results will be presented first, followed by the qualitative results.

5.2 Quantitative results

The quantitative data were obtained using four instruments, namely the pre- and post-test, the attitude and LEMOSS questionnaires. These instruments were discussed in Chapter 4 Section 4.4. The following table will summarise the different types of comparisons which were possible between the pre- and post-tests and between the experimental and control groups who wrote the pre- and post-tests:

Control group	Experimental group
Pre-test	Pre-test
Post-test	Post-test

- The pre-test averages of the experimental and control groups were compared.
- The post-test averages of the experimental and control groups were compared.
- The pre- and post-test averages of the experimental group were compared.
- The pre- and post-test averages of the control group were compared.

The results obtained from these comparisons will be presented in the following sections.

5.2.1 Pre-test results comparison between the experimental and control groups

The experimental and control groups wrote exactly the same pre-test. As explained in Section 4.4.1, the pre-test actually served to create two groups of learners who were statistically identical and thus comparable. This means that the two groups did not differ significantly in any of the test questions and therefore not on the test average either. The pre-test, like the post-test, was mainly knowledge-based. The pre- and post-tests were not identical in terms of the questions asked, the formulation or sequence of questions. The pre-test could not intentionally address issues on the technological process and in particularly biogas, because the subjects had not been exposed to it directly prior to the interventions. If learners were given exactly the same test for pre- and post-test comparison purposes, the pre-test could have prepared the experimental and control learners for the post-test to an extent. To avoid this problem, but to enable comparisons to be made between the two groups, it was decided to use the same concepts in the pre-test and post-test, but to formulate the questions in a different way and to change the context in which a particular concept was assessed.

Each question in the pre-test was classified by the researcher according to the cognitive taxonomy of Bloom. The specific cognitive level will be indicated next to each question. The classification of each question was validated by the science and technology teachers who were initially involved in setting the test. The pre-test questions, as well as the Bloom taxonomy level for each question, will be presented below:

Table 5.1: Pre-test: An energy and energy efficiency technology-science test

Pre-test: An energy and energy efficiency technology-science test

Question 1:Cognitive level on Bloom's taxonomy: Knowledge

How would you explain the concept "energy" to a friend? Write this explanation down. (4)

Question 2:Cognitive level on Bloom's taxonomy: Knowledge and comprehension

Should wood be classified as a fossil fuel or a non-fossil fuel? Give reasons for your answer. (4)

Question 3:Cognitive level on Bloom's taxonomy: Knowledge and comprehension

When you switch on the study lamp in your room, not all the electrical energy is transferred into light energy. Use this example to explain what is meant by energy efficiency. (5)

Question 4:Cognitive level on Bloom's taxonomy: Comprehension

On a cold winter's day, your mother's motor car does not want to start because the battery is flat. What type of energy is associated with a motorcar's battery. Why does jumpstarting get the motorcar going again? (5)

Question 5:Cognitive level on Bloom's taxonomy: Application

When a fire brakes out in your classroom, you should not open all the windows, but rather close them all and get out. Explain whether there is sense in this drill and give reasons for your argument. (5)

Question 6:Cognitive level on Bloom's taxonomy: Application

The heater you use in winter is powered by electricity. Select the correct answer:

The amount of heat emitted by the electrical heater is

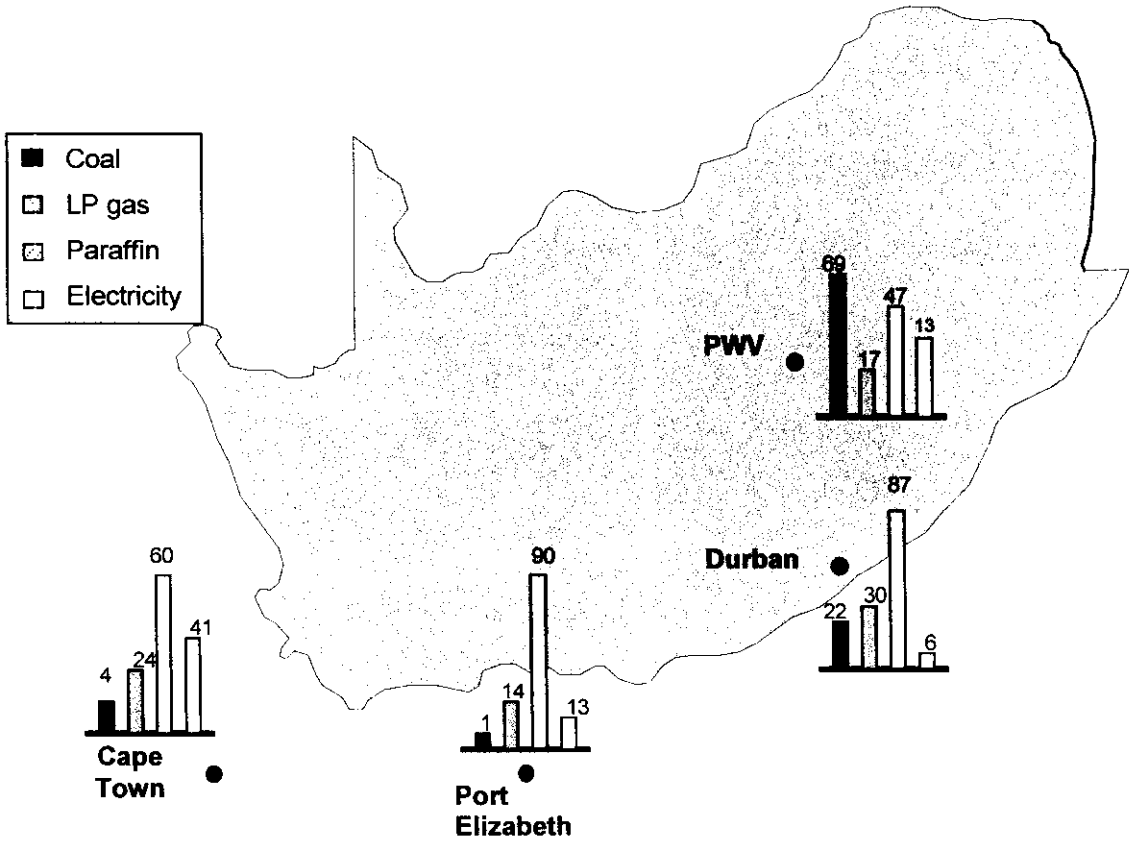
- A) exactly the same as the amount of electrical energy supplied.
- B) less
- C) more

Explain the reasons for your decision. (5)

Question 7: Cognitive level on Bloom's taxonomy: Comprehension

Study the diagram below (Mineral and Energy Policy Centre, 1996:21):

Which of the cities in the diagram is most likely to contribute to pollution? Give reasons for your answer. Remember to consider how electricity is generated before you attempt to answer this question. (5)



7.1 Cognitive level on Bloom's taxonomy: Comprehension

Which of the cities in the diagram is most likely to contribute to pollution? Give reasons for your answer. Remember to consider how electricity is generated before you attempt to answer this question. (5)

7.2 Cognitive level on Bloom's taxonomy: Application/comprehension

Households in rural areas mostly make use of paraffin, which is a by-product from refining oil, for their energy needs. What do you think is the reason for this? (4)

7.3 Cognitive level on Bloom's taxonomy: Application

Calculate the total percentage of electricity users at the coast. Do the same for users of coal. How do these two groups compare with one another? (4)

Question 8:

8.1 Cognitive level on Bloom's taxonomy: Comprehension

Wood and coal may both be used as sources of energy. Explain what the health and environmental effects of these sources are. (3)

8.2 Cognitive level on Bloom's taxonomy: Application

Eight million tons of wood is yearly burnt as domestic fuel in South Africa. What do you foresee will the result of this fact be on South Africa?

What advice will you give to the people using the wood? (3)

8.3 Cognitive level on Bloom's taxonomy: Knowledge

Provide a list of resources which may be considered as substitute resources for wood and coal. (3)

8.4 Cognitive level on Bloom's taxonomy: Knowledge

What do you think will be a good substitute energy resource for wood and coal particularly in South Africa? Give reasons for your answer. (3)

Question 9: Cognitive level on Bloom's taxonomy: Analysis/synthesis

As an energy expert, you are asked to write a brosjure with tips on how to decrease a family's monthly electricity bill in summer and winter months. (6)

Question 10: Cognitive level on Bloom's taxonomy: Analysis/synthesis

Explain to a friend how you will plan and prepare an experiment to show that energy is transferred from one form to another. (10)

TOTAL: 70

P-values, also known as exceedance probability, were calculated to determine whether meaningful differences existed between the experimental and control groups' test averages (Steyn, Smit, Du Tiot & Strasheim, 1996:420). This is the same data table that was presented in section 4.5.2.2 in Table 4.8.The data set had a normal tendency, but was not

perfectly normally distributed. Therefore a **Wilcoxon sign rank sum test** was executed for a non- symmetrical data set to determine the exceedence probability (p – value) (Steyn, Smit, Du Tiot & Strasheim, 1996:594 and Keller & Warrack, 2000:513).

Table 5.2: Pre-test results comparison per group

	Pre-test		p-value Wilcoxon sign rank sum test (p-value)
	Mean (X)	Std. dev (s)	
Experimental group N = 70	61,7857	15,7847	0,7990
Control group N = 70	61,8286	15,6899	

The p-value did not indicate a meaningful difference between the experimental and control group averages for the pre-test. This result indicated that the two groups started off on an equivalent knowledge basis prior to any research interventions. There was no significant difference between the experimental and control groups for individual questions. The mean and standard deviation for each question will therefore not be presented. This, however, will be the case with the post-test where significant differences for individual questions were present.

5.2.2 Post-test results comparison between the experimental and control groups

Both the experimental and control groups wrote the post-test after the one month intervention. The post-test was statistically analysed for each question. The experimental and control groups were compared to determine whether a meaningful difference existed between the mean scores of each question and for the test total. P-values were calculated to determine whether meaningful differences existed between the experimental and control groups (Steyn, Smit, Du Tiot & Strasheim, 1996:420).

The experimental and control groups are for statistical purposes regarded as two

independent sample populations. This particular data set was tested for symmetry, which it did not have. Therefore a distribution-free test, called the **Mann-Witney rank sum test** was used to calculate the p-values (Steyn, Smit, Du Tiot & Strasheim, 1996:594 and Keller & Warrack, 2000:513). A distribution-free test is not dependent on whether a sample population is normally distributed on the basis of the central limit theorem.

The post-test itself will be presented before the post-test results will be presented. Each question, as in the pre-test, was classified by the researcher according to the cognitive taxonomy of Bloom. The specific cognitive level will be indicated next to each question.

Table 5.3: Post-test: The energy and energy efficiency technology-science test

Post-test: The energy and energy efficiency technology-science test

Question 1: Cognitive level on Bloom's taxonomy: Knowledge

What is energy? Describe it in your own words. (4)

Question 2: Cognitive level on Bloom's taxonomy: Knowledge and comprehension

What is chemical energy? Also give examples of chemical energy resources. (5)

Question 3: Cognitive level on Bloom's taxonomy: Knowledge and comprehension

Describe what you understand by the term "fossil fuels". Give examples of fossil fuels and non-fossil fuels. (5)

Question 4: Cognitive level on Bloom's taxonomy: Comprehension

Most of the chemical energy stored in motorcar fuel (petrol) is not used to move the car when combusted. Most of the chemical energy is transformed into another form of energy, namely heat energy. Use this example to explain the concept of energy efficiency. (5)

Question 5: Cognitive level on Bloom's taxonomy: Application

When you make a fire for some reason or another, such as preparing food or for heat in winter, you sometimes need to help the fire to get going effectively. What would you do to get the fire going? What methods will you use? Explain why you sometimes need to help the fire in this particular way. (5)

Question 6: Cognitive level on Bloom's taxonomy: Application

Electricity is used to light (power) a light bulb. Select the correct answer:

The amount of light energy emitted by the light bulb is

a) more

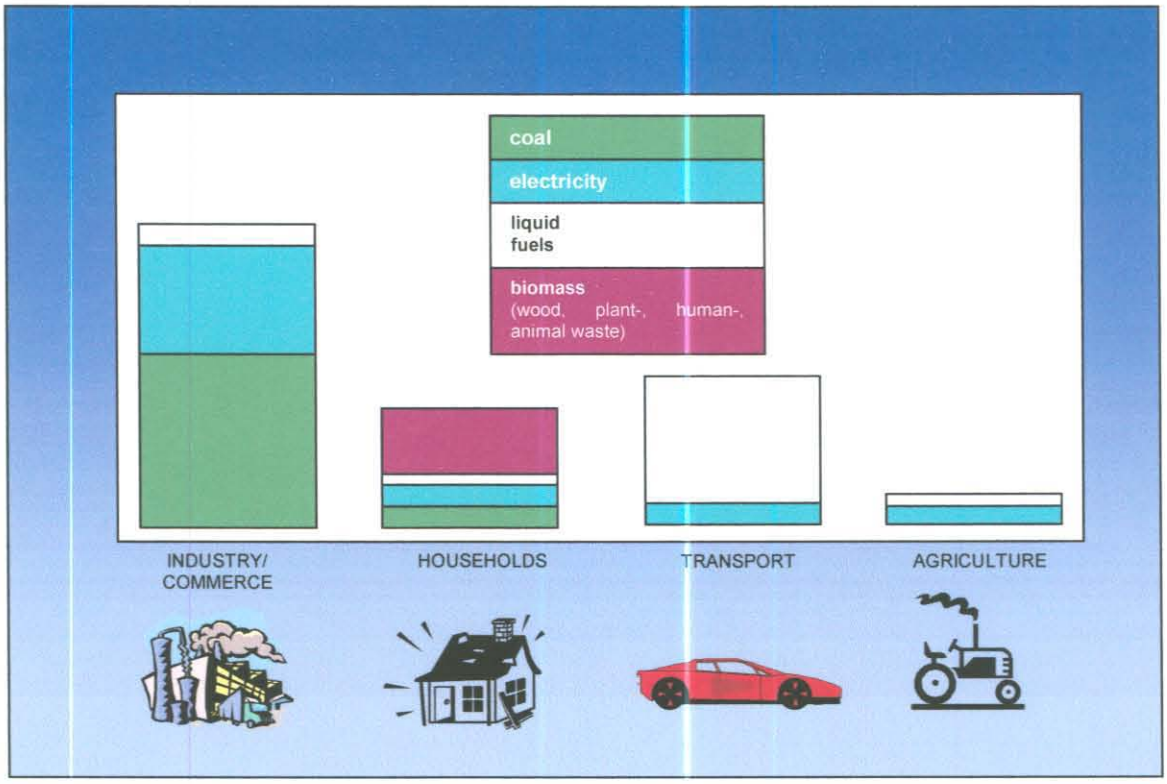
b) less

c) exactly the same as the amount of electrical energy supplied.

Give reasons for your answer. (5)

Question 7:

Study the diagram below (Mineral and Energy Policy Centre, 1996:20):



7.1 Cognitive level on Bloom's taxonomy: Comprehension

Use the diagram to name the energy source which is mostly used by each of the four groups of energy users. (5)

7.2 Cognitive level on Bloom's taxonomy: Application/comprehension

Give reasons why you think a particular resource is mostly used by each of the groups of energy users. (5)

7.3 Cognitive level on Bloom's taxonomy: Analysis

Which of these groups of energy users are most likely to contribute to air pollution? Give reasons for your answer. (5) (15)

Question 8

8.1 Cognitive level on Bloom's taxonomy: Knowledge

Explain what alternative energy resources are and give examples of alternative resources. (3)

8.2 Cognitive level on Bloom's taxonomy: Knowledge

You did a project on energy and energy efficiency. In the problem which you had to solve you had to focus on biogas. Would you classify biogas as an alternative energy resource? Give reasons for your answer. (3)

8.3 Cognitive level on Bloom's taxonomy: Comprehension

Explain what biogas is. Also give a chemical reaction to illustrate how biogas is formed. (4)

[10]

Question 9: Cognitive level on Bloom's taxonomy: Analysis/synthesis

As an energy expert, you are consulted to do an environmental impact study before a factory plant can be built which will produce biogas on a large scale. Advise the interested role players on the following regarding biogas as an alternative energy form:

- The advantages of biogas.
- The disadvantages of biogas.
- The possibilities of biogas.

Use a table format to present your advice (6)

Question 10: Cognitive level on Bloom's taxonomy: Analysis/synthesis

Tell a friend how you will go about designing a model or a prototype for a technological device such as a biogas maker. (10)

TOTAL: 70

Please comment on your personal experience of the new method of teaching which was used for this project:

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Thank you for your participation!

Note: This blank space was left at the bottom of the post-test for learners of the experimental group, to write comments on their experiences of the new method that was used for teaching and learning. These qualitative learner comments will be addressed and related to empirical results obtained from the attitude questionnaire in Section 5.2.6.

The post-test results for the experimental and control groups will be presented in Table 5.4. The results of each question, as well as the test totals, will be given. Next to each question number, the marks allocated to that question will be indicated in brackets.

Table 5.4: Post-test comparison between experimental and control group

	Experimental group		Control group		p-value
	Mean (X)	Std. dev.(s)	Mean (X)	Std. dev.(s)	Mann-Witney Rank sums
Question 1 (4)	3,1617	0,7453	3,5362	0,6769	0,0016**
Question 2 (5)	3,2794	0,7697	3,4203	0,8644	0,3895
Question 3 (5)	2,7647	0,9943	3,9420	0,8023	0,0000**
Question 4 (5)	3,3235	0,7811	3,3043	0,8099	0,9170
Question 5 (5)	4,0588	0,8443	2,5797	0,8297	0,0000**
Question 6 (5)	3,3088	0,6749	3,4348	0,7761	0,4282
Question 7 (15)	8,8823	2,2026	9,2319	2,1223	0,3460
Question 8 (10)	5,8235	1,0782	6,0000	1,1882	0,4722
Question 9 (6)	4,5147	1,0147	3,2898	0,8419	0,0000**
Question 10 (10)	6,5441	1,2629	5,1159	0,9631	0,0000**
Test total: Percentage	65,1321	11,5564	62,7244	9,8546	0,2652

** $p < 0,01$
* $p < 0,05$

For question 1 and 3 the p-values are smaller than 0,01. This means that the higher mean scores of the control group for these two questions are significantly higher than the mean scores of the experimental group. It means that the probability that the difference occurred by chance was less than 1%.

It seems that the direct instruction strategies enhanced performance in these two questions. Both these questions represented the lower cognitive levels of the Bloom taxonomy. These two questions were classified on the knowledge and/or comprehension cognitive levels.

For questions 5, 9 and 10 the experimental group scored significantly higher than the control group. Question 5 was classified under the application cognitive level, while the other two

represented the higher cognitive levels in Bloom's taxonomy. It seems that the PBL strategies enhanced performance in these three questions. The **total** test average of 65,13 % of the experimental group is higher than the control group's total test average of 62,72 %. This difference however, is not statistically significant.

5.2.3 Pre- and post-test results comparison per group

P-values were calculated to determine whether a meaningful difference between the pre- and post-test totals existed for each of the experimental and control groups. The data set was tested and showed a normally distributed tendency, but it was not perfectly normal. For statistical purposes the pre- and post-tests are regarded as two dependent sample populations. The distribution-free test which was used for the two dependant sample populations, is called the **Wilcoxon sign rank sum test** (Steyn, Smit, Du Tiot & Strasheim, 1996:594 and Keller & Warrack, 2000:513). This is the oldest and best known of the distribution-free tests according to Steyn, Smit, Du Tiot & Strasheim (1996:594, 589).

Table 5.5: Pre- and post-test results comparison per group

	Pre-test		Post-test		Mean difference between pre-and post-test	Mean Std. dev. (s)	p-value
	Mean (X)	Std. dev. (s)	Mean (X)	Std. dev. (s)			Wilcoxon sign rank sum test
Experimen-tal group N = 70	61,7857	15,7847	65,1321	11,5564	3,2647	9,3019	0,0133*
Control group N = 70	61,8286	15,6899	62,7244	9,8546	1,2029	9,4768	0,6710

** $p < 0,01$

* $p < 0,05$

The post-test mean score for the experimental group is significantly higher than the pre-test mean score. It can be assumed with 95% (Wilcoxon sign rank sum test) certainty that the

PBL intervention was responsible for the meaningful improvement from the pre- to the post-test. This, however, cannot be claimed for the control group.

5.2.4 Results from the attitude questionnaire

Only the experimental group who had the PBL interventions completed this questionnaire to determine their attitude towards PBL and related issues. Frequency counts for each option and each question were calculated and presented as a percentage.

Table 5.6: Attitude questionnaire for the experimental group

ATTITUDE QUESTIONNAIRE FOR THE EXPERIMENTAL GROUP						
Surname and Name: ..... Respondent Number: ..... Encircle the number of your choice.Eg. 1 2 (3) 4 5 **Numbers 1 to 5 have the following meaning:** **1 = not at all** **2 = not too much** **3 = I don't know** **4 = quite a lot** **5 = very much**		**Not at all**	**Not too much**	**I don't know**	**Quite a lot**	**Very much**
1	Did you learn anything valuable from this particular task?	1	2	3	4	5
2	Was the research kit of any help to you?	1	2	3	4	5
3	Did you make use of the research checklist which was part of the kit?	1	2	3	4	5
4	Do you enjoy this new method in the teaching of a subject?	1	2	3	4	5
5	Do you think it is valuable to work in small groups with fellow learners?	1	2	3	4	5
6	Do you prefer to rather work on your own?	1	2	3	4	5
7	Did you have to work hard to execute this task?	1	2	3	4	5
8	This method has helped me to learn how to solve problems.	1	2	3	4	5

Results from the attitude questionnaire

The results from each question in the attitude questionnaire will be summarised in table format. The largest percentage of learners who chose a particular option will be highlighted in the table.

Question 1:Did you learn anything valuable from this particular task?

Response options	Frequency count	Percentage(%)
1	4	4,0
2	15	15,0
3	16	16,0
4	**58**	**58,0**
5	7	7,0

Question 2:Was the research kit of any help?

Response options	Frequency count	Percentage(%)
1	0	0,0
2	2	2,0
3	8	8,0
4	41	41,0
5	**49**	**49,0**

Question 3:Did you make use of the research checklist which was part of the kit?

Response options	Frequency count	Percentage(%)
1	1	1,0
2	7	7,0
3	11	11,0
4	**47**	**47,0**
5	34	34,0

Question 4: Do you enjoy this new method and approach in the presentation of a subject?

Response options	Frequency count	Percentage(%)
1	1	1,0
2	12	12,0
3	11	11,0
4	30	30,0
5	**46**	**46,0**

Question 5: Do you think it is valuable to work in small groups with fellow learners?

Response options	Frequency count	Percentage(%)
1	7	7,0
2	8	8,0
3	11	11,0
4	28	28,0
5	**46**	**46,0**

Question 6: Do you prefer to rather work on your own?

Response options	Frequency count	Percentage(%)
1	23	23,0
2	**26**	**26,0**
3	17	17,0
4	16	16,0
5	18	18,0

Question 7: I had to work hard to execute this task.

Response options	Frequency count	Percentage(%)
1	3	3,0
2	4	4,0
3	14	14,0
4	17	17,0
5	**62**	**62,0**

Question 8: This method has helped me to solve problems.

Response options	Frequency count	Percentage(%)
1	4	4,0
2	13	13,0
3	14	14,0
4	20	20,0
5	**49**	**49,0**

This questionnaire provides results which help to form a general picture of the learners' attitude towards PBL and towards specific elements related to PBL, such as the research kit, meta-learning checklist, and the value and enjoyment related to co-operative learning.

Throughout, the majority of learners selected option 4 (quite a lot) or 5 (very much), which indicates a generally positive attitude towards the particular elements referred to in the questions. The formulation of question 6 however, elicited the selection of option 2 (not too much) as the majority option. It is interesting to note that the results of question 5 and 6 are related. In question five, 46% of the learners indicated that it is very valuable to work in groups, while question 6 indicates that only 23% enjoy it very much to work co-operatively. Throughout all the questions, option 3 (I don't know) was not selected as a majority option. The number of learners who selected this option varied between 11 and 17. These empirical results will later (see Section 5.2.5) be used again when the learner comments are discussed.

5.2.5 The relation between the LEMOSS, achievement and the attitude questionnaire

The Learning and Motivation Study Strategy questionnaire (LEMOSS) was completed by the experimental group after the one month intervention. The function of the LEMOSS was to identify the following attributes and competencies in experimental group learners:

- Level of problem-solving competency.
- Extrinsically motivated learners.
- Intrinsically motivated learners.

Once their problem-solving competency was determined, the experimental group was divided into two groups – one with **low** and the other with **high problem-solving competency**. A strategy had to be implemented which could divide the learners

scientifically into the two groups. The LEMOSS was trailed by Basson, Goosen & Swanepoel (1996) with 984 senior secondary learners in public South African schools from the same demographic area as some of the schools which were used in this research. The mean value for the problem-solving category which emanated, was 33,6 (Basson, Goosen & Swanepoel, 1996:62,66). All the learners who scored an average higher than 33,6 were classified as learners with above average (high) problem-solving competency. The same process was used to classify learners with below average (low) problem-solving competency.

The mean values for the categories intrinsic and extrinsic motivation are 16,0 and 15,6 respectively. Where the intrinsic motivation score of a particular learner was higher than the mean intrinsic motivation score and higher than the extrinsic motivation score, that learner was classified as an intrinsically motivated learner. The same principle was applied to identify extrinsically motivated learners.

Apart from the categorisation based on the LEMOSS fields, learners were also categorised, based on their post-test **achievement**. They were divided into two groups, the below average and the above average achievers. Achievement was classified as below average when a score was lower than the post-test average of 65% (rounded off from 65,13%), that is 64% and under. Achievement of 66% and higher was classified as above average achievement. The statistical calculations determined the extent to which these two groups preferred a particular option in the attitude questionnaire.

Once the classification of above and below average problem-solving, intrinsically/extrinsically motivated groups, and below and above average achievers, were completed, analysis with regard to the attitude questionnaire could commence. This particular statistical analysis attempts to determine if any one of these groups had a preference to select a particular option in the attitude questionnaire. Options 1 and 2 in the attitude questionnaire were combined and collectively described as **"not at all"** in the tables below, while option 4 and 5 combined described **"very much"**. Option 3 which is **'I do not know",** is a neutral option. This option was therefore ignored for the Fisher's Exact Two Tail Test, which is only designed to do comparisons in a two by two matrix. The statistical test

used, was the Fisher's Exact Two Tail Test.

All the tables, except for two, inform us that the different groups did not have a preference to select a particular option. That means that it was a random phenomena for any of the groups to select any option. Two of the tables however, gave the following information:

Table 5.7: Meaningful differences in achievement: This method has helped me to learn how to solve problems

ACHIEVEMENT: This method has helped me to learn how to solve problems			
• Percentage % • Number of learners	Not at all	Very much	Row percentage
Below average	21,2 (n=15)	27,2 (n=19)	48,4
Above average	8,1 (n=5)	43,6* (n=31)*	51,6
Column percentage	29,3	70,7	100
Fisher's Exact Test (2-tail): 0,025* Right tail value: 0,016* Left tail value: 0,997			

* $p < 0,05$

The Fisher's Exact Two Tail Test (Fisher, 1935 & Daniel) indicates that significant differences are present in the two by two matrix. The significant differences can be present in rows and/or columns. The right tail test value indicates that the significance lies in one of the two right quadrants of the matrix. The particular extreme value to be identified is the 43,6%. This means that the above average learners have a significant preference to select "very much" for this particular statement in the attitude questionnaire. 31 of the 70 learners who selected the "very much" option, were above average, while only 5 of the above average achievers selected "not at all". In other words, it was significant that six times as many above average achievers indicated that PBL has helped them very much to learn how

to solve problems, compared to above average achievers who said PBL did not help them at all in this regard.

Although not significantly different, the below average achievers showed the same tendency in the selection of the "very much" option as the above average achievers. More below average learners, namely 19, also selected the "very much" option compared to the 15 who selected the "not at all option". This however, is not a significant ratio.

Another question which elicited meaningful differences in responses, was whether learners enjoyed PBL as a teaching strategy. The term "method" is used in the question, because learners are more familiar with this term. One would have expected that extrinsically motivated learners and learners with above average problem-solving skills would have a meaningful preference to indicate that they enjoy PBL very much. This was not necessarily the case. The category of above average achievers enjoyed PBL significantly "very much", as shown in the results below:

Table 5.8: Meaningful differences in achievement : Do you enjoy this new method in the teaching of a subject?

ACHIEVEMENT: Do you enjoy this new method in the teaching of a subject?			
Percentage % Number of learners	Not at all	Very much	Row percentage
Below average	25,0 (n=18)	23,5 (n=16)	47,5
Above average	14,5 (n=10)	37,4* (n=26)*	51,9
Column percentage	39,5	60,9	100
Fisher's Exact Test (2-tail): 0,042* Right tail value: 0,046* Left tail value: 0,986			

* $p < 0,05$

The right tail test value again indicates that the significance lies in one of the two right quadrants of the matrix. The particular extreme value to be identified is 37,4%. This means that the above average learners have a significant preference to select "very much" for this particular question in the attitude questionnaire. 26 of the 70 learners who selected the "very much" option, were above average and 10 of the above average achievers selected "not at all". In other words, more than twice as many above average achievers enjoyed learning through PBL, as opposed to the above average achievers who did not enjoy PBL at all. This is a meaningful difference. For the below average achievers, there was not a significant difference between the learners who selected "not at all" and "very much". The number of below average achievers selecting these options are almost the same; 18 below average achievers said they did not enjoy PBL, while 16 enjoyed PBL.

In the rest of the two by two matrixes there were no meaningful preferences present. No particular group had a meaningful preference to select either "not at all" or " very much". In other words, whether a learner is intrinsically or extrinsically motivated, has below or above average problem-solving skills, they do not have particular preferences related to the different questions asked in the attitude questionnaire. The rest of the results are also presented here:

MOTIVATION: Did you learn anything valuable from this task?			
Percentage % Number of learners	Not at all	Very much	Row percentage
Extrinsic	12,1 (n=8)	53,5 (n=37)	65,6
Intrinsic	5,2 (n=4)	29,3 (n=21)	34,5
Column percentage	17,3	82,8	100
Fisher's Exact Test (2-tail): 1,000			

In the row showing the responses of extrinsically motivated learners, it appears that a significant difference should be present for the "very much" option, but it is not. Nearly the same ratio of below average achievers have selected the "very much" option as the above average achievers. This means that five times as many extrinsically motivated learners have selected the "very much" option, while six times as many intrinsically motivated learners have also selected the same option. In other words the two groups exhibited similar preferences in their answers to this question. Therefore, no significant preferences are present in the rows or columns.

In several of the following tables, a similar situation occurs. That is, the ratio of the "very much" to the "not at all" options is high in each row, but because it is similar for the two rows there is no overall significant difference. The tables showing a similar tendency will be presented below. The other tables where there is no similar tendency, will be presented directly after the similar tendency tables.

Tables showing a similar tendency:

MOTIVATION: Did you learn anything valuable from this task?			
Percentage % Number of learners	Not at all	Very much	Row percentage
Below average	11,8 (n=17)	36,8 (n=26)	48,6
Above average	7,4 (n=5)	44,1 (n=31)	51,5
Column percentage	19,2	80,9	100
Fisher's Exact Test (2-tail): 0,3630			

The preferences of the below- and above-average achievers were similar.

PROBLEM-SOLVING: Did you learn anything valuable from this task?			
Percentage % Number of learners	Not at all	Very much	Row percentage
Below average (<33,5)	4,4 (n=3)	16,4 (n=12)	20,8
Above average (>33,5)	14,7 (n=10	64,6 (n=45)	79,4
Column percentage	19,1	81,0	100
Fisher's Exact Test (2-tail): 1,000			

MOTIVATION: Was the research kit of any help to you?			
Percentage % Number of learners	Not at all	Very much	Row percentage
Extrinsic	1,8 (n=1)	64,3 (n=45)	66,1
Intrinsic	0,0 (n=0)	33,9 (n=24)	33,9
Column percentage	1,8	98,2	100
Fisher's Exact Test (2-tail): 1,000			

ACHIEVEMENT: Was the research kit of any help to you?			
Percentage % Number of learners	Not at all	Very much	Row percentage
Below average	0,0 (n=0)	45,6 (n=32)	45,6
Above average	3,1 (n=2)	49,2 (n=34)	52,3
Column percentage	3,1	94,8	100
Fisher's Exact Test (2-tail): 0,493			

PROBLEM-SOLVING: Was the research kit of any help to you?			
Percentage % Number of learners	Not at all	Very much	Row percentage
Below average (>33,5)	1,5 (n=1)	18,5 (n=13)	20
Above average (<33,5)	1,5 (n=1)	78,5 (n=55)	80
Column percentage	3	97	100
Fisher's Exact Test (2-tail): 0,362			

MOTIVATION: Do you enjoy this new method in the teaching of a subject?			
Percentage % Number of learners	Not at all	Very much	Row percentage
Extrinsic	27,6 (n=19)	37,9 (n=27)	65,5
Intrinsic	13,8 (n=10)	20,7 (n=14)	34,5
Column percentage	41,4	58,1	100
Fisher's Exact Test (2-tail): 1,000			

PROBLEM-SOLVING : Do you enjoy this new method in the teaching of a subject?			
Percentage % Number of learners	Not at all	Very much	Row percentage
Below average (<33,5)	7,4 (n=5)	13,2 (n=9)	20,6
Above average (>33,5)	32,4 (n=23)	47,1 (n=33)	79,5
Column percentage	39,8	60,3	100
Fisher's Exact Test (2-tail): 1,000			

MOTIVATION: Do you think it is valuable to work in small groups with fellow learners?			
Percentage % Number of learners	Not at all	Very much	Row percentage
Extrinsic	25,0 (n=18)	41,1 (n=28)	66,1
Intrinsic	14,3 (n=10)	19,6 (n=14)	33,9
Column percentage	39,3	60,7	100
Fisher's Exact Test (2-tail): 0,780			

ACHIEVEMENT: Do you think it is valuable to work in small groups with fellow learners?			
Percentage % Number of learners	Not at all	Very much	Row percentage
Below average	24,6 (n=17)	26,2 (n=18)	50,8
Above average	15,4 (n=11)	33,9 (n=24)	49,3
Column percentage	40	60,1	100
Fisher's Exact Test (2-tail): 0,207			

PROBLEM-SOLVING : Do you think it is valuable to work in small groups with fellow learners?			
Percentage % Number of learners	Not at all	Very much	Row percentage
Below average (<33,5)	7,7 (n=5)	12,3 (n=9)	20
Above average (>33,5)	32,3 (n=23)	47,7 (n=33)	80
Column percentage	40	60	100
Fisher's Exact Test (2-tail): 1,000			

MOTIVATION: Do you prefer to rather work on your own?			
Percentage % Number of learners	Not at all	Very much	Row percentage
Extrinsic	31,0 (n=22)	34,5 (n=24)	65,5
Intrinsic	15,5 (n=11)	19,0 (n=13)	34,5
Column percentage	46,5	53,5	100
Fisher's Exact Test (2-tail): 1,000			

ACHIEVEMENT: Do you prefer to rather work on your own?			
Percentage % Number of learners	Not at all	Very much	Row percentage
Below average	22,1 (n=15)	26,5 (n=19)	48,6
Above average	22,1 (n=15)	29,4 (n=21)	51,5
Column percentage	44,2	55,9	100
Fisher's Exact Test (2-tail): 1,000			

PROBLEM-SOLVING: Do you prefer to rather work on your own?			
Percentage % Number of learners	Not at all	Very much	Row percentage
Below average (<33,5)	10,3 (n=7)	10,3 (n=7)	20,6
Above average (>33,5)	33,8 (n=24)	45,6 (n=32)	79,4
Column percentage	44,1	55,9	100
Fisher's Exact Test (2-tail): 0,764			

MOTIVATION: Did you have to work hard to execute this task?			
Percentage % Number of learners	Not at all	Very much	Row percentage
Extrinsic	7,0 (n=5)	57,9 (n=34)	64,9
Intrinsic	1,8 (n=1)	33,3 (n=23)	35,1
Column percentage	8,8	91,2	100
Fisher's Exact Test (2-tail): 0,647			

ACHIEVEMENT: Did you have to work hard to execute this task?			
Percentage % Number of learners	Not at all	Very much	Row percentage
Below average	6,0 (n=4)	14,8 (n=29)	20,8
Above average	3,0 (n=2)	49,3 (n=35)	52,3
Column percentage	9,0	64,1	100
Fisher's Exact Test (2-tail): 0,414			

PROBLEM-SOLVING: Did you have to work hard to execute this task?			
Percentage % Number of learners	Not at all	Very much	Row percentage
Below average (<33,5)	0,0 (n=0)	20,9 (n=15)	20,9
Above average (>33,5)	9,0 (n=6)	70,2 (n=49)	79,2
Column percentage	9	91,1	100
Fisher's Exact Test (2-tail): 0,330			

MOTIVATION: This method has helped me to learn how to solve problems			
Percentage % Number of learners	Not at all	Very much	Row percentage
Extrinsic	22,2 (n=16)	42,6 (n=29)	64,8
Intrinsic	9,3 (n=7)	25,9 (n=18)	35,2
Column percentage	31,5	68,5	100
Fisher's Exact Test (2-tail): 0,760			

PROBLEM-SOLVING SKILLS: This method has helped me to learn how to solve problems			
Percentage % Number of learners	Not at all	Very much	Row percentage
Below average (<33,5)	4,8 (n=3)	12,9 (n=9)	17,7
Above average (>33,5)	24,2 (n=17)	58,1 (n=41)	82,3
Column percentage	29	71	100
Fisher's Exact Test (2-tail): 1,000			

Tables showing a random phenomena:

MOTIVATION: Did you make use of the research checklist which was part of the kit?			
Percentage % Number of learners	Not at all	Very much	Row percentage
Extrinsic	44,8 (n=31)	20,7 (n=15)	65,5
Intrinsic	15,6 (n=11)	19,0 (n=13)	34,6
Column percentage	60,4	39,7	100
Fisher's Exact Test (2-tail): 0,098			

It is interesting to note that twice as many extrinsically motivated learners *did not* use the checklist compared to the extrinsically motivated learners who did use it. The purpose of the checklist was to stimulate the reflective thinking and meta-learning-abilities of learners. It seems that the extrinsically motivated learners have used one another in the co-operative

groups to reflect on ideas – true to the nature of extrinsically motivated learners who derive their stimuli from their external environment. The comments made by the learners will pick up on this idea.

ACHIEVEMENT: Did you make use of the research checklist which was part of the kit?			
Percentage % Number of learners	Not at all	Very much	Row percentage
Above average	30,9 (n=21)	17,6 (n=12)	48,5
Below average	26,4 (n=19)	25,0 (n=18)	51,4
Column percentage	57,3	42,6	100
Fisher's Exact Test (2-tail): 0,337			

PROBLEM-SOLVING: Did you make use of the research checklist which was part of the kit?			
Percentage % Number of learners	Not at all	Very much	Row percentage
Below average (<33,5)	8,8 (n=6)	11,8 (n=8)	20,6
Above average (>33,5)	48,5 (n=34)	30,9 (n=21)	79,4
Column percentage	57,3	42,7	100
Fisher's Exact Test (2-tail): 0,241			

5.2.6 General conclusion: Quantitative results

The most salient results that emerged from this section are the following:

(i) The pre and post knowledge-based test

There were no significant differences between the experimental and control groups' pre-test results. This indicated that the two groups started off on an equal knowledge basis. The post-test revealed that there were significant differences between the experimental and control groups in five test questions. In two lower cognitive questions, according to Bloom's taxonomy, the control group performed significantly better. In two higher and one lower cognitive question, the experimental group achieved significantly higher scores. Although the experimental group had a higher **total test average** than the control group, the total test average of the two groups did not differ significantly.

Although there was no significant difference in the test total between the experimental and control groups, the pre- and post-test comparisons **per group** reveal that the experimental group performed significantly better in the post-test than in the pre-test. This increase may be ascribed to the PBL strategy which was used to operationalise technology education within the OBE framework. This was not the case with the control group.

(ii) The attitude of the experimental learners towards the OBE-PBL experience

A summary of the results obtained from the attitude questionnaire will be given in this section. For each result, learner quotes will be presented. That is, if there were appropriate comments available from the comments data base. Each quote which will be used, will attempt to enrich the empirical data, in that it will give insights beyond empirical numbers. Additional remarks will be made by the researcher about particular issues arising from the learner comments. Learners from the experimental group had an opportunity to write comments directly after they wrote the post-knowledge test. 28% of the learners commented on the content of the problem and solutions to it. 2% of the learners responded with a single word such as "nice", while 9% did not respond with a written comment. The rest, which constitute 61% of the experimental group, did write comments about the new method of

teaching and learning which was used for the "project", as they called it. Prior to each comment, it will be indicated whether a learner was a low or high achiever, extrinsically or intrinsically motivated and had below or above average problem-solving skills. The post-test mark obtained by the learner will also be indicated. Some comments may be used under more that one empirical result.

Attitude result 1:

65% of the learners in the experimental group felt that they did **learn something valuable** from the PBL task, while 19% felt they did not learn very much.

Learner comment:

(Mark 40%, below average achiever, extrinsically motivated):

The project was really valuable and fun. Although – we missed a lot of syllabus work during this project and fell behind classes which were not involved in this project.

Additional remarks:

Although this low achiever is concerned about not covering the syllabus, she still evaluates PBL to be "really" valuable and fun. The less structured learning environment, which is characteristic of PBL, is experienced as "a little bit confusing". This learner is still more comfortable with direct instruction and the old paradigm of learning where a teacher should work through the resource materials in a step-by-step fashion with learners. This comment is characteristic of a learner who has not yet made a paradigm shift about what learning is and how it occurs.

Learner comment:

(Mark: 58%, below average achiever, extrinsically motivated, below average problem-solving skills):

I did not learn very much from this project, because the topic had nothing to do with our syllabus.

Additional remarks:

This below average achiever perceives syllabus work, which is purely content-based, to be the only valuable work from which he can learn something worthwhile. It must be remembered that all the tests and exams will only be on syllabus topics and therefore this learner is rightfully concerned about his marks and passing. Currently, progress and promotion is still only based on a learner's quantitative assessment of tests and exams. There are no obvious incentives for this learner to experience learning beyond the regular work and methods.

Learner comment:

(Mark: 70%, above average achiever, extrinsically motivated, above average problem-solving skills):

It can be of great advantage if we can use this method more often in class. This project in particular is very successful. I enjoyed working on this project with my friends.

Additional remarks:

This above average learner seems to have had positive experiences with the PBL task and will even like to use it more often in the classroom situation. This comment supports the two empirical results obtained from the Fisher's Exact Two Tail Test. The empirical results indicated that the above average achievers enjoy PBL and that the strategy has taught them

how to solve problems significantly better than the below average achievers. This extrinsically motivated learner also enjoyed co-operative work.

Attitude result 2:

90% of the learners in the experimental group said that the research kit was very helpful, while 2% indicated that it was not very useful.

Learner comment:

(Mark 71%, above average achiever, intrinsically motivated, above average problem-solving skills):

It is good to do something different than the normal, which is to work from textbooks. It is good to focus on nature itself. However, for a project like this, the time must be enough. For this project it was maybe a little bit too short. For the rest there are no complaints.

Additional remarks:

Doing something different seems to motivate this above average achiever. Since PBL demands using more resources than the textbook and a teacher, the learner needs more time to get involved in his research and problem-solving.

Learner comment :

(Mark 55%, below average achiever, extrinsically motivated, below average problem-solving skills):

The presentation of the project was confusing. The teacher must work through the notes with us and help us to study it.

Additional remarks:

A below average learner asks for structure and direct guidance. In other words, he feels safe within the structured environment he became used to over his years of schooling, where a teacher directs most of the learning. This might be expected of learners with below average problem solving skills.

Attitude result 3:

81% of the learners in the experimental group used the research checklist, while 8% did not use it very often.

No applicable comments are available. The Fishers Exact Two Tail test showed that 31 of the 70 learners who did *not* use the research checklist at all, were extrinsically motivated. Only 15 of the extrinsically motivated learners used the research checklist very much. It may be assumed that the extrinsically motivated learners get their stimulus and monitor their progress from the outside environment, such as the co-operative group members. 13 intrinsically motivated learners used the research checklist, while 11 did not.

Attitude result 4:

76% of the learners in the experimental group indicated that they **enjoyed** the "new method and approach" to teaching, while 13% did not enjoy it very much.

Learner comments:

(Mark 58%, below average achiever, intrinsically motivated, above average problem solving skills):

I think it is very nice and I enjoy it to do things on my own every now and then. One do not only sit on your chair and write frantically like a zombie. I enjoy it.

Additional remarks:

Where the Fisher's Exact Two Tail Test showed that the majority of below average achievers did not enjoy PBL, this particular below average achiever did enjoy working on his own now and then, and especially the fact that he was not treated like a "zombie".

Learner comments:

(Mark 69%, above average achiever, intrinsically motivated, below average problem-solving skills):

I really enjoy these hands-on technology projects. It places science in a new, different light.

Additional remarks:

The learner's reference to hands-on projects indicates that PBL stimulated the learner and involved activity-centred learning experiences which this learner enjoyed. The PBL technology experience seems to have motivated the learner, since he sees science in a new light.

Learner comments:

(Mark 30%, low achiever, intrinsically motivated, below average problem-solving skills):

I do not like it. You waste valuable academic time, which my parents are paying for. We wasted time with senseless group debates. Just give us our books and let us learn.

Additional remarks:

This was one of the lowest achievers in the post-test. This learner begs for direct guidance and structure. He felt very lost in the PBL environment and consequently did not like the PBL experience. This comment also proves that this particular learner who will finish school

in two years time, has not been prepared by the schooling he received for the real life roles he will have to demonstrate after school. The particular critical outcome related to solving problems using critical and creative thinking, which was addressed by this PBL task, does not seem to be cultivated by the traditional approaches this learner is comfortable with. His dislike is portrayed as a type of aggression.

Maybe if the pre-service teacher was aware of this, he/she could have given more direct support emotionally and also with the solution of the problem. It seems that a pre-service training programme for OBE-PBL should make pre-service teachers competent to proactively diagnose potential problems, such as this one, especially if the learning challenge is very different from what learners became used to over their years of schooling.

Note: One would expect high achieving, intrinsically motivated, good problem solvers to enjoy PBL and find it valuable. There was not a particular quote from a high achieving, intrinsically motivated learner with above average problem-solving skills to support this expectancy. One female from these categories did however said that *"it was a nice challenge"*.

Attitude result 5:

74% of the learners in the experimental group experienced **co-operative work as valuable**, while 15% did not agree.

Learner comments:

(Mark 50%, low achiever, extrinsically motivated, below average problem-solving skills):

It was a good attempt to get children to work together and to get them to think on their own.

Additional remarks:

Although this learner is a below average achiever with low problem-solving skills, she also

experienced or suspects that PBL, as it was facilitated by the pre-service teacher, can contribute towards learners thinking on their own, as well as working together.

Learner comments:

(Mark 30%, low achiever, intrinsically motivated, below average problem-solving skills):

We wasted time with senseless group debates.

Additional remarks:

This comment indicates that the PBL task as facilitated by this pre-service teacher, achieved exactly what it aimed to achieve. That is lively debates which forced learners to think critically and meta-cognitively about what they were actually suggesting and why they were suggesting it during the problem-solving process. The fact that this below average learner is intrinsically motivated, might contribute to her not feeling very comfortable learning in a co-operative group. This, however, is a real life role that she should get practice in and although she cannot see the "sense" in the group debates, she will hopefully unconsciously have been prepared or sensitised to an extent for life beyond the grade 10 curriculum.

(Mark 59%, below average achiever, extrinsically motivated, below average problem-solving skills):

This method does not work effectively, because people do not work together in a group. One *person has to do everything. Learners who were suppose to gather particular information did not bring it to all group members. If our general knowledge was better, our project also would have worked better.*

Additional remarks:

This learner seems to attribute the ineffectiveness of the method to learners not working effectively in a group, rather than the fact that learning is organised around problems. It

should also be kept in mind that learners have never done serious learning in a co-operative setup which has to adhere to very specific criteria. The most they have done in groups, not co-operative learning groups, were practical sessions where five or six learners stood at the same working bench when doing an experiment. One or two normally executed the recipe like procedures of the experiment, while the others tried to write down observations or results. They are not used to working together in a constructive manner, where each co-operative member takes responsibility for his or her particular task and to solve cognitive or social conflict productively. It seems that the traditional schooling they became very used to in their ten years of schooling did not really prepare them to cultivate the critical outcome which deals with working together **effectively** as a member of a team. The PBL task with its associated co-operative learning strategy, did challenge the learners to start working effectively in teams. The last comment on general knowledge also indicates that this learner was led to reflect on his and his groups' cognitive resources.

Attitude result 6:

It is interesting that while 74% of the learners in the experimental group find co-operative work valuable, only 49% of the learners in the experimental group **enjoy working in co-operative groups** and 34% do not enjoy working in co-operative groups.

Learner comment :

(Mark 70%, above average achiever, extrinsically motivated, below average problem-solving skills):

It is enjoyable to work in a group, but can be confusing. We missed out on work and consequently we will not cover the syllabus. The result will be bad marks.

Additional remarks:

It is not surprising that an extrinsically motivated learner enjoys co-operative work. Since this leaner is an above average achiever, she is typically concerned about not covering the content-heavy syllabus on which she will be examined. It seems that learning is driven by an

achievement approach and not an internal locus of control or deep approach to learning. In an achievement and competition driven society, where best achievement is awarded by extrinsic means such as bursaries and trophies at the end of the year, it is not surprising that content coverage and good marks are the major motivators for this above average learner.

Learner comment :

(Mark 30%, low achiever, intrinsically motivated, below average problem-solving skills):

We wasted time with senseless group debates.

Additional remarks:

It makes sense that an intrinsically motivated learner is not very comfortable with co-operative work, even more so because it is something new to the way in which he is used to learning in class. The purpose of the SAQA critical outcome, which focuses on working together as a member of a team, is to prepare this learner in school for real-life outside of school where he will have to help groups or teams to "make sense" when engaging in debates.

Attitude result 7:

79% of the learners in the experimental group indicated that they **had to work very hard** to execute the task, while 7% said that it was not necessary to work very hard to execute the task. Fisher's Exact Two Tail test showed that *all* the learners with below average problem-solving skills indicated that they had to work very hard, while 70% of the above average problem-solvers also indicated that they had to work very hard. Only 9% of the learners with above average problem-solving skills said they did not have to work hard. The same tendency occurred with the extrinsically and intrinsically motivated learners and with the above and below average achievers. (See Section 5.2.4).

Learner comment :

(Mark 52%, below average learner, extrinsically motivated, below average problem-solving skills):

The method is fine, we just need a little bit more time for all the research. A job done in a rush, is a job half done.

Additional remarks:

Various reasons may be given for why the learners said that they really had to work very hard and that that they needed more time. First, PBL is learner-centred and engages learners actively in their learning process. What the learners had to do to solve the problem involved much more time and effort than using a textbook, answering end-of-chapter questions, executing pre-designed experiments and designs. The PBL design provided them with no opportunity to be passive and to transfer the responsibility for their own progress to the teacher. The teacher of course, always remains responsible for the progress in the learning process as was explained in Section 3.2.1. Secondly, the learners from the experimental group did not receive the problem-solution, with an appropriate design in a pre-packed format. The nature of the PBL task was open-ended and they had to brainstorm points of departure and possible solutions. They finally had to do more with their theoretical suggestion for an effective solution – they had to make their ideas work by building a prototype, model or the final device. Thirdly, the PBL and co-operative practice were new to them. They had to become familiar with a few unfamiliar practices. These reasons might contribute to the fact that they had to work hard to execute the task and to the fact that more time would have come in handy for them.

This comes as no surprise, since learning through PBL takes more time than learning the same content and skills through direct instruction. More time could have been provided, seeing that learners were not familiar with PBL and its associated strategies. The duration of the school practice period at this particular university is one month (20 school days). This intervention with the experimental group took up the whole month.

Learner comment :

(Mark 72%, above average achiever, intrinsically motivated, above average problem-solving skills):

I do feel that more time can be allocated for the project.

Attitude result 8:

69% of the learners in the experimental group indicated that the PBL method has **helped them to learn how to solve problems**, while 17% feel that it did not help them very much in this regard.

Learner comment :

(Mark 72%, above average achiever, extrinsically motivated, above average problem-solving skills):

The project was interesting. It was something new. You do not have to learn everything like a parrot. It is nice to do things and practical work on your own. You get to work with something that you don't know at all and get to know it through your involvement.

Additional remarks:

This learner is an above average achiever and feels empowered by the fact that he could work on his own and not in a prescriptive, parrot-like fashion. The challenge engaged him to such an extent that he requires more time. It seems that this PBL task has motivated this particular learner both intrinsically and extrinsically.

Concluding remarks

The learners' experiences of PBL and its related strategies reflect varying attitudes, some more negative and the majority more positive. The selected learner comments add richness to the empirical data, in that they provide insight into specific empirical responses. One of the constants coming to the surface is that both below and above average achievers have

asked for more time to be engaged in the PBL task. It seems that learners realise that to be successful in PBL, they need to be engaged in depth with the issues and particularly resources related to the problem. Actually, the nature of PBL demands this involvement and commitment from learners. The one month period, with six to seven thirty minute periods per five day school week, did not seem to be enough time. Learners who were very successful with the execution of the PBL task, did put in a lot of extra effort in their own time after school.

Although the majority of learners had positive attitudes, reasons must be found to determine why some had negative attitudes. Some of the comments showed that certain learners did not like working co-operatively, although they valued it. Others were not comfortable in the less-structured learning environment created by PBL. They still want learning to be teacher-centred and textbook driven methods with which they are familiar. The majority felt empowered by the responsibility and active learner-centred approach to learning. The negative attitudes might not only be attributed to PBL and its associated strategies, but also to the fact that learners were concerned about falling behind other classes, which could result in bad test and exam marks. It is interesting to note that very low and very high achievers had the same concerns in this regard. This is the reality and a problem to be dealt with when doing research in real organisations such as schools. These are also the concerns of principals, teachers and governing parent bodies, which sometimes hinder research where it really matters – in authentic situations with multiple complexities. Also see Section 4.5.2.1 for more reasons why principals did not allow this research to be undertaken in their schools.

(iii) The Fishers Exact Two Tail Test:

The above average achievers had a significant preference to select the "very much" option to the following two questions/statements:

- This method has helped me to learn how to solve problems.

- Do you enjoy this new method in the teaching of a subject?

For the rest of the questions, the below and above average achievers and problem-solvers, as well as the extrinsically and intrinsically motivated learners, did not have a particular preference for or against PBL and its associated strategies. What is worth noting, is that all the categories of learners indicated overwhelmingly that they really had to work very hard to execute the PBL task. This may have been a function of the particular PBL task – it is not necessarily an indication that learners would always have difficulty with PBL. However, the fact remains that the nature of this PBL task and PBL in general, engages learners in high levels of activity and responsibility.

5.3 Qualitative results

Qualitative data were obtained from the six pre-service teachers who voluntarily opted to implement the OBE-PBL model in real classrooms for one month. Prior to their PBL training, these teachers reported in writing on their conceptualisation of technology, technology education and effective teaching strategies for this learning area. After their PBL training on how to facilitate learning in technology from an OBE framework, and their one month experience in practice, they were interviewed. They also kept log-books of their day-to-day activities, experiences and reflections on their teaching practice. The data from the pre-intervention questionnaires, post-intervention interviews and log-books, will be analysed, coded and the results presented in the following sections.

5.3.1 Method of qualitative data analysis

When it comes to qualitative data analysis, much has been described and prescribed by experts in the field. Poggenpoel (1998:337) however, says that "*there is no right or wrong approach to data analysis in qualitative research*". Although there is no single blue-print for qualitative data analysis, there are, however, proven guidelines and strategies which may be utilised by a researcher.

A process of coding described by Bogdan & Biklen (1992: 166-167) and Modingwa (1995: 26-27) has been used as a guideline for developing the coding scheme. While reading through the data the reasoning strategies called "bracketing" and "intuiting" have been

applied.

Burns & Grove (1987:80) explain that to bracket, the researcher "*suspends or lays aside what is known about the experience being studied*" so that an open context can be achieved. In other words all preconceived ideas are placed between brackets. Intuiting normally takes place after bracketing to get a sense of the whole (Modingwa, 1995:26). Burns & Grove (1987:80) explain intuiting as

- *... the process of actually 'looking at' the phenomenon....This is thought to allow an increase in insight. Intuiting requires absolute concentration and complete absorption with the experience being studied.*

Video tape recordings of the classroom interventions also exist for selected parts of the PBL training of the pre-service teachers, as well as for their practice interventions. Due to practical circumstances, video recordings were not made of all the pre-service teachers. It was therefore decided not to analyse and code the video clips, but they were used for the purpose of intuiting to get a **holistic** impression before and after the other qualitative data were analysed and coded.

After the researcher familiarised herself with the qualitative data sets and applied the strategies mentioned previously, the task of developing a coding scheme had to start. A coding scheme consisted of code categories and sub-code categories. Although different software programmes such a ATLAS/ti exist, which can assist in the development of a coding scheme, the actual coding and the analysis of the data, it was decided to do the coding and analysis manually. The number of respondents and the data generated by them in this research, were manually manageable. The ATLAS/ti software is particularly useful when an unstructured or open instrument is used to generate data. All the instruments used to gather data in this research were semi-structured. This meant that prominent coding and sub-coding categories were already present in the instruments before the data analysis started.

The first codes were generated from the conceptual framework of the researcher and deduced from the questions which were present in the pre-intervention questionnaire and

the post-intervention interview schedule. The researcher was also open to other code categories, which might emerge from the meaning constructed by the respondents (Poggenpoel, 1998:338). These code categories emerge when certain phrases, behaviours, events and ways of thinking repeat themselves to represent a pattern (Bogdan & Biklen, 1992:166).

The code categories were labelled with numbers (eg. 1, 2,..). The need arose to also identify sub-code categories which were labelled as 1.1, 1.2, etcetera. It must be mentioned that some units of data were coded with more than one code or sub-code category.

After the coding scheme was finalised the data were coded by the researcher. The following code categories were identified:

- **Code 1:** Perception of technology and technology education prior to the training intervention.
- **Code 2:** Perceptions and conceptions of technology and technology education after the training intervention.
- **Code 3:** Pre-service teachers' experience of PBL training.
- **Code 4:** Pre-service teachers' experience with PBL in practice.
- **Code 5:** Pre-service teachers' perception of outcomes-based education after the PBL training and practice experience.

The sub-codes which are related to each of the codes will be presented when the qualitative results are discussed.

5.3.2 *Results: Perceptions of pre-service teachers prior to the PBL training intervention*

The first set of qualitative data was obtained from written opinions and perceptions from the pre-service teachers before the problem-based training for technology education started. Since none of the prospective teachers had any experience of teaching at the beginning of the year when their professional studies in senior secondary education commenced, no pre-perceptions regarding education related issues were determined. It was therefore not established whether the pre-service teachers had a common understanding of OBE or whether they had similar levels of teaching expertise. An exercise if this nature would have been irrelevant for the pre-service teachers. What was established will be discussed in the following section.

All the pre-intervention opinions and understandings regarding technology, technology education and appropriate teaching strategies were established. These pre-intervention perceptions will be represented by code 1. It is therefore labelled as "Perception of technology and technology education prior to the training intervention". Each of the six questions in this open-ended questionnaire represents a sub-code which will be indicated next to the question in Table 5.7 below. No additional sub-codes came to the fore. Pre-service teachers responded to each of these questions and their responses will be coded with one or more of the sub-codes. The following table shows the questions and the sub-codes which were derived from each question:

Table 5.9: Code 1: Perceptions of technology and technology education prior to the training intervention

Code 1: Perceptions of technology and technology education prior to the training intervention	
Questions	**Sub-codes**
What is technology? Explain	1.1: Perception of technology
What is technology education? Explain	1.2: Perceptions of technology education

Is there a difference between technology and natural science?	1.3: Difference between technology and natural science
What is the most effective methodology for the teaching of technology?	1.4: Effective methodology for teaching technology
What are the phases in the technological process?	1.5: Phases in the technological process
Do you think that South African education is ready to implement technology?	1.6: SA readiness for implementing technology.

Results obtained from the qualitative data will be presented in a narrative format, with reference to specific quotes where it contributes to strengthening an argument. Typical answers and remarks recurring frequently will also be presented as quotations. A typed copy of the pre-service teachers' written comments is attached as Appendix 6.

Results of Code 1: Perception of technology and technology education prior to the training intervention

Sub-code 1.1: Perceptions of technology

Technology was broadly described by pre-service teachers as progress, new developments and discoveries through research, which makes life easier, better and simple. Five pre-service teachers described technology as computers, software and electronic equipment which may be used to enhance the quality of products. One pre-service teacher did not attempt to explain what technology is, but gave the following answer:

- *Personally I don't believe that there is one person who can give an exact definition of technology. For me the word has a very broad meaning. I tend to think about computers and all the modern electronic equipment. However, I know that technology is much more than that.*

Sub-code 1.2: Perceptions of technology education

The majority started their answers by saying the learners should be exposed to modern technology such as computers, which the learners will need in their lives. Two said that technology education should be more than exposure, but that learners should get the opportunity to make their own equipment and improve on existing ones.

The notion that technology is associated with a process was also mentioned twice:

- *... it is about teaching them the processes which should be used to discover equipment for themselves and to improve on it.*

- *It is the facilitation of skills which learners have to learn to apply in technology, as well as developing a thinking process where learners have to think beyond the here, now and the known.*

Sub-code 1.3: The difference between technology and science

Four of the six pre-service teachers feel that there is a difference, but that these areas are also inextricably linked. A typical comment is given:

- *Natural science studies the natural laws (etc) and theories ... technology is where certain aspects of science are implemented in practice.*

The idea of technology as applied science is highlighted by the following two quotations:

- *Technology rather focuses on the utilisation possibilities (and the production of products) of basic science understandings and concepts.*

- *Scientists do the research to develop basic knowledge which engineers then can use to design, develop, produce and improve ideas.*

Sub-code 1.4: Effective approach or method for teaching technology

Although none of the pre-service teachers had any experience in technology and no experience in teaching at the beginning of the year, they voiced their opinions and suggestions in this regard. The suggestion that technology should be practically taught, was embraced by four of the pre-service teachers. Here are two of the comments by the pre-service teachers:

- *Technology is a very practical subject and..... learners will have to think for themselves.*
- *Practical investigations and experiments by learners, but especially research by the learners themselves about the latest technological developments. Teaching has to be done by someone who knows enough and who is interested in the subject, else it would only be another dead subject.*

Sub-code 1.5: Phases in the technological process

The majority, which comprise five pre-service teachers, said that they did not know what the phases of the technological process are. One speculated that it was maybe the same as the steps in the scientific process:

- *Maybe it is like the scientific process of hypothesising, experimenting (repeat and accurate). Verify or reject the hypothesis, formulate a theory and finally produce a final product.*

One of the pre-service teachers came very close to the technology process as it is conceptualised in South African curricula:

- *I don't know, maybe it is: identify a problem, find a solution, test, evaluate and implement – it actually is the same steps which engineers use.*

Sub-code 1.6: SA readiness for implementing technology

Pre-service teachers who said that South Africa is not ready to implement technology, ascribe it to the lack of funds, lack of adequately qualified and trained facilitators and minimum facilities. As one said : *"There is not even enough money to buy text books. In private schools where funds are available, it will work*". One did mention that the lack of resources is not supposed to be a limiting factor because "*the whole subject is about solving problems!".*

Two pre-service teachers remarked that South Africa is ready:

- *Yes, I think we have the necessary facilities and competent people to teach such a subject.*
- *SA has a lot of potential, but not the necessary funds to keep up with first world countries. If it's not about money, Yes.*

These results, which were obtained before the training, will later be compared with results obtained after the training and practice experiences of the pre-service teachers.

5.3.3 Results from the interviews with the pre-service teachers and their log-books.

The interviews were conducted by the researcher after the training and practice intervention, when the pre-service teachers had enough time to reflect on their experiences. Appropriate extracts from the daily kept log-books will be used when applicable. The translated transcripts are included as Appendix 7.

Two of the pre-service teachers who worked as a team at one of the schools asked to be interviewed simultaneously. Since they did form an effective team in the same school, the request was granted. The other interviews were conducted on a one-to-one basis. The main codes which were used for analysing the interviews are:

- **Code 2:** Perceptions of technology and technology education after the training intervention.

- **Code 3:** Pre-service teachers' experience in PBL training.

- **Code 4:** Pre-service teachers' experience with PBL in practice.

- **Code 5:** Pre-service teachers' perceptions of outcomes-based education after the PBL training and practice experience.

Results of Code 2: Perceptions of technology and technology education after the training intervention

Three sub-codes emerged from the interview data for code 2, which are presented in the Table 5. 8 below:

Table 5.10: Code 2: Perceptions of technology and technology education after the training intervention

Code 2:	**Perceptions of technology and technology education after the training intervention**
Interview question: How would you explain to a parent or fellow student what technology education is?	
Sub-code 2.1:	Problem-based perception
Sub-code 2.2:	Process perception
Sub-code 2.3:	Creative challenge

Sub-code 2.1: Problem-based perception

The initial perception which was held by many pre-service students that technology education is merely about exposing learners to computers and other high-tech equipment, which they will need in their lives, was not mentioned once. The perception that technology

is focused towards the identification and solution of problems and needs was a popular one:

- *It teaches learners how to think to solve problems.*

- *To teach children to identify problems, to look for solutions, to produce a product or system and to evaluate it. Technology is need-driven.*

Sub-code 2.2: Process perception

Pre-service teachers continued to explain that the solution of a problem involves more than just a final product or system as outcome. They describe and value the process of getting to the solution. One pre-service teacher said that the processes involved in technology education might even help learners to develop generic skills which they might find useful in their lives.

- *He has to recognise a problem, seek a solution, design and make and finally evaluate the end product. In the process he learns an enormous amount of skills during the resource tasks, which will help him to develop into a useful person.*

- *I still think it is not only about products, but about a thinking process.*

Sub-code 2.3: Creative challenge

The following two pre-service teachers experienced technology as a learning area which enhances creative endeavours:

- *Well, in technology education, like in science education learners have to discover and explore on their own. In technology education they have to design and make their own ideas – they are not given a design to just copy and make.*

- *Finding solutions to problems, is something that cannot be given – the*

individual has to look for it by doing thorough research.

Results of Code 3: Pre-service teachers' experience of PBL training

Table 5.11: Code 3: Pre-service teachers' experience of PBL training

Code 3:	**Pre-service teachers' experience of PBL training**
Interview question: How did you experience the problem-based approach in your training?	
Sub-code 3.1:	PBL as a valuable learning experience – ascribed to its practical nature
Sub-code 3.2:	PBL as an unstructured approach
Sub-code 3.3:	PBL experienced as learner-centred and resource-based with high levels of activity
Sub-code 3.4:	PBL experienced as co-operative learning
Sub-code 3.5:	PBL experienced as inducing creativity
Sub-code 3.6:	Other application possibilities of PBL

The sub-codes give an indication of the breadth of the pre-service teachers'experiences with PBL.

Sub-code 3.1: PBL as a valuable learning experience – ascribed to its practical nature

Four pre-service teachers experienced PBL as a very valuable learning experience, although it was different from what they were used to in their previous university experiences in their under-graduate studies. The following quotations will highlight what it is that the pre-service teachers value about their PBL training:

- *I like new things, I liked it very much. Yes, this was the one subject in which I have learnt the most in the whole year. Exept for learning how to design lesson presentations, I also learnt a lot about the subject which I will teach as well.*

It seems that pre-service teachers contribute the value of PBL to what they experienced as the practical, hands-on nature of it. They also mention what PBL intends to achieve with learning – that is to make it more relevant which will enhance the transferability of competence to the work place and every day lives.

- *I feel that this training was very practically orientated and relevant and it is this fact which made the course successful. I have personally grown and I believe so have my fellow students.*
- *Wow – it was really different to what we were used to – but subject didactics is supposed to be more practical than our formal lectures. And it was really practical orientated.*

The two pre-service teachers who worked as a team highlighted the fact that PBL was instrumental in helping them to bridge the gap between knowledge acquisition and the ability to apply it:

Interviewer: *Did the PBL approach help in any way?*

Pre-service teacher A: *Well yes, technology and OBE is all about using your knowledge and by giving us problems, we learn how to apply our own knowledge.*

Pre-service teacher B: *I don't think we know enough about technology education but at least we know something about the methodology of teaching it.*

Interviewer: *What is that methodology?*

Pre-service teacher A: *Well that learners must do their own research and set-up their own experiments if they want to investigate something.*

Sub-code 3.2: PBL as an unstructured approach

Just like some of the learners, one pre-service teacher experienced PBL as an unstructured or ill-structured approach to teaching and learning. This pre-service teacher prefers a highly structured learning environment and says that PBL will work in a subject-didactics class, but not for all subjects. Unfortunately she does not provide a reason for her intuitive opinion.

Pre-service teacher: *Mm – I think at first I found it a loose approach. I am one of those people who like structure.*

Interviewer: *Briefly explain what you mean by structure?*

Pre-service teacher: *I guess I like well organized presentations. I must say that I use the word presentation rather than lecture because it fits better into this new stuff. We also don't prepare "lessons" anymore but learning opportunities.*

Interviewer: *(Yes) tell me more about your training experience.*

Pre-service teacher: *I didn't know anything about technology – at least I understand technology better now and that technology is all about solving some needs of society and that is why you gave us all the (unclear on tape) ... I mean problems to solve. I don't think that all subjects can be presented like this, but it will work in a subject didactics class.*

Sub-code 3.3: PBL experienced as learner-centred and resource-based with high levels of activity

Three pre-service teachers commented on the fact that PBL actually compelled them to become actively involved in the learning process. The activity-based experiences can be related to the various stages and activities associates with PBL. One of the compulsory

stages is the research phase, where they had to access and utilise information resources while trying to generate solutions to the posed problems. This research seems to have achieved the outcome of getting pre-service teachers to read extensively and to motivate them to put extra effort in. Three pre-service teachers reported the following:

- *It kept us very busy because we couldn't find all the answers of what we were suppose to do in textbooks – because you didn't prescribe any.*
- *All the extra effort I had to put in looking for relevant problem settings forced me to look beyond textbooks.*
- *For the problems which we had to do first, before one went to the schools, I actually landed up in the Department of Biochemistry. I had some valuable discussions with lecturers there which broadened my horizons.*

During one of the problem-based sessions, they discovered the Teachers' Library in Pretoria, which is valuable resources centre available to all registered South African teachers. At this resource centre they can access information in the form of video's, films, computer software, internet addresses, wall charts, professional transparencies, books, popular and refereed journals which they may use in their future problem-designs as well.

Sub-code 3.4: PBL experienced as co-operative learning

Being final year students busy with a post-graduate professional diploma in secondary education, they should have been well aware of the criteria and advantages of co-operative learning. In general the pre-service teachers report very positively about their experiences with co-operative learning. They mention that what they have experienced as very valuable in co-operative learning is brainstorming, dividing responsibilities among one another and the opportunity to practice the social skill of learning to work with fellow learners. This is however, also one of the seven SAQA critical outcomes in OBE. They had the following to say about their experience of co-operative learning:

Pre-service teacher A: *Well I am glad that you divided us into groups to do the tasks.*

Interviewer: *Why?*

Pre-service teacher A: *It makes a big task like this much easier and we know all the benefits of group work.*

Interviewer: *What are they?*

Pre-service teacher B: *We brainstorm – the more ideas, the better. We share the research work amongst ourselves, and we learn how to work with fellow students. That's why "A" and I decided to do the project together at High School C.*

One pre-service teacher associated continuous assessment with co-operative learning. She valued the immediate feedback provided by co-operative members. This comment strengthens the argument that co-operative learning is a strategy which may be used to stimulate meta-learning and critical thinking skills:

- *By means of co-operative learning we could assess one another on a continuous basis, and we received valuable ideas and information from one another.*

Sub-code 3.5: PBL experienced as inducing creativity

One pre-service teacher felt that she was challenged to be creative when designing problem-based learning tasks in technology education. It is ironic that she did not have this experience intentionally in any of her former studies. It should be remembered that she was in her 16th year of official learning (12 years of school, 3 years for her BSc degree, 1 year for her post-graduate professional teaching diploma) in her life:

- *At the beginning of the year I could not think creatively at all, because it was never necessary to be creative. Your approach has challenged me to develop my creative thinking to such an extent that I can think diverse about problems and solutions.*

Sub-code 3.6: Other application possibilities of PBL

Two pre-service students indicated that PBL has training possibilities for the other Learning Areas as well, while one pre-service teacher felt that it was not the case:

- *Finally I think that this approach will not only work for technology, but for many other subjects as well.*

Another pre-service teacher however, did not share his peers' opinion:

- *I don't think that all subjects can be presented like this, but it will work in a subject-didactics class.*

Results of Code 4: Pre-services teacher's experience with PBL in practice

Table 5.12: Code 4: Pre-services teacher's experience with PBL in practice

Code 4: Pre-services teacher's experience with PBL in practice
Interview question: Part 1: How did the learners experience the PBL approach? Think of your classroom experiences. Part 2: Tell me more about how you facilitated the PBL in practice.
Sub-code 4.1: Learner attitudes
Sub-code 4.2: Problems experienced by learners and pre-service teachers
Sub-code 4.3: The learners' experience of co-operative learning
Sub-code 4.4: Quality of learning

Sub-code 4.1: Learner attitudes

The pre-service teachers experienced the initial attitude of learners as one of excitement and enthusiasm. This attitude changed somehow when the learners realised that they really had to put some effort in to solve the problem. Three of the pre-service teachers report as follows about learner attitudes:

- *In the beginning they were very enthusiastic because it was something new and different. (But) after three weeks the enthusiasm of some faded, because they realised it was not just a play-play task. The time came closer to demonstrate their energy devices.*
- *Learners were exited about the whole thing after they were presented with the problem. They have asked to work in groups themselves and the class was divided into four groups with five to six learners per group.*
- *Some of them thought it was playtime because they didn't have formal lessons. For some of them the idea of doing the whole task as a group was the greatest attraction of the whole thing.*

In the last phase of the project, the learners presented their technological energy devices to a "board of experts from The Department of Minerals and Energy". In her log-book one teacher wrote that one of the groups showed a negative attitude when they refused to do the presentation due to being unprepared on the day of their final solution presentation. She mentioned that this all-boys group was one of the groups who thought that the non-formal structure of PBL learning environments meant play time and socialisation with co-operative team members. They said that *"they did not prepare and that they only want to write the test to finish this whole project off"*. Learners will also have to take up their responsibility and must show accountability in a learner-centred environment created by PBL. This however, will not come instantly for learners who also have to make a paradigm change about alternatives for effective teaching and learning.

In the following scenario the positive attitude of the pre-service teacher seemed to rub off on

to all partners involved in the PBL learning experience. The pre-service teacher who arranged a coal mine field trip in Ellisras, experienced the practice situation as follows:

- *Personally I think that the learners in this school have gained very much from this whole project. The problem forced them to use different resources, apart from the kit they received. I know that we had to do the same things in the different schools, but I decided to arrange a field-trip to a coal mine where they could see energy and technology in action. My husband is an engineer there, so it was quite easy to organise it. I thought if other schools could use internet as an extra resource, I can use the coal mine experience as an extra resource.*

- *The principal liked the idea so much that he said he would appreciate it if the whole grade 10 science group could go. I received so much support from the principal and the science teachers. I think everybody enjoyed the technology with its new approach.*

- *When the learners had to build their biogas maker – I had to stop the parents from doing it. One farther wanted to build a real big thing for his daughter's group.*

This particular pre-service teacher makes the following comment, which highlights one reason why her learners and their parents had positive attitudes towards PBL. It is embedded in her personal teaching philosophy:

- *I gave them a lot of motivation, and I believe if you show your enthusiasm they get it from you.*

Sub-code 4.2: Problems experienced by learners and pre-service teachers

Initially the problems experienced by learners and pre-service teachers were coded as two separate categories. After applying the reasoning principle of intuiting, it was realised that some of the problems experienced by learners are actually related, or can be traced back to the problems which the pre-service teachers have experienced. See Section 5.2.5 where the empirical results are presented together with comments made by the learners themselves.

Some of the learners could not understand why they were being treated differently from the other class, which was the control group. They requested the following from the pre-service teacher:

Pre-service teacher A: *They also wanted the notes which the other class received, but "B" explained it nicely to them.*

Interviewer: *Mmm?*

Pre-service teacher B: *Yes, I told them that we didn't want to teach them facts only, but also the process of working through the facts to be able to do something useful with the facts. They understood this idea quite well. I must say that I am glad that we were two students.*

Interviewer: *Why?*

Pre-service teacher B: *I think if a facilitator doesn't know what he is doing it can be chaos in a big class.*

Interviewer: *Why do you say that?*

Pre-service teacher B: *There is a lot of noise and the more exited they become, the louder they speak. They also move around a lot.*

The next section of the interview with pre-service teacher A and B illustrates the nature of the problems experienced simultaneously by learners as well as the pre-service teachers. It can be speculated that some learners tend to loose interest towards the end, due to the lack of experience on the part of the pre-service teachers in group facilitation skills. The following quotation suggests that these particular pre-service teachers had a narrow view of how to teach the OBE-PBL way:

Pre-service teacher A: *Some of the groups were fine, but I was really worried about some of the groups. It seemed that they loose interest if they*

really don't see their way out. Although we encouraged them not to loose heart. I know that I am a facilitator who is not supposed to transfer, but sometimes I felt like doing it.

Pre-service teacher B: *I agree with "A". I think we still need a lot of experience in working with co-operative groups. The easy way out will be just to tell them what they need so that they could progress.*

In another section of the interview pre-service teacher A made the following comment about her role and function as facilitator of learning:

- *... but you can't just leave them, some won't investigate anything if you just leave them.*

She also suggested a possible solution to the problem that some learners were not committed to work:

- *It will help if you know the learners and then put them into a group which will pull them along.*

Another pre-service teacher described her actions during the act of facilitating learning. When describing her practice experience, she also mentions moments of frustration experienced by learners. After she explained what she did in the control class she continued explaining how she facilitated the experimental group. This explanation also shows a narrow view of how to facilitate learning according to the OBE-PBL way:

- *In the other class I moved in between the different groups all the time. Actually all I did was to encourage and motivate them. Although they asked me questions when I reached a group, I didn't really give them any hints, because the idea is that they do the work, isn't it? Sometimes I got the idea that some individuals were very frustrated with this method.*

Another pre-service teacher also communicated a need or problem experienced when she

said *"it was difficult for me to determine how much feedback to give them"*. She remarked as the follows:

- ***Pre-service teacher**: It took a lot of my energy to work in this way. All the learners wanted your attention at the same time. If a co-operative group shows you their progress it was difficult for me to determine how much feedback to give them.*
- ***Interviewer:** What feedabck did you give them?*
- ***Pre-service teacher:**My feedback was of the nature: 'That's OK', 'It's great' , 'You need to rethink this', 'You need to add something' and so on.*

In one of the log-books a pre-service teacher wrote the following:

Day 1:

The problem was presented to the learners.

- *Each learner had the opportunity to experience it individually.*
- *They then asked if they could work in groups – a question which we anticipated. They were divided into co-operative groups as suggested by their regular teacher.*
- *Instead of brainstorming and discussing it with their group members, I was showered with questions. I didn't really know whether I was supposed to answer all or some of these questions. I think some of the learners were just chancers who were too lazy to tackle the problem and wanted me to give them shortcuts, I think. I might be wrong.*

In the final conclusion on these results more will be said about the training needs of pre-service teachers in their new role as facilitators of learning in an OBE-PBL learning environment, which came to the fore in this interview.

Sub-code 4.3: The learners' experience of co-operative learning

In the initial design of the experimental group intervention, it was decided not to divide learners into groups straight away. Only after each of the learners had a thorough personal experience and a basic understanding of the problem, it was anticipated that they would request to work together, from where they would be divided into groups. The rationale behind this decision was to give learners ownership of their request, which would contribute towards commitment towards the group and the project.

For some learners, as was already reported, one of attractions of the project seems to be the fact that they could work together. Usually learners only work together on an ad hoc basis when they do practical work, but not in an organised way according to criteria which are valid for co-operative learning. (See Section 3.4.3 for criteria to design co-operative work.) One pre-service teacher explains how she facilitated co-operative learning:

- *Normally they work in groups when they do practical work only – but then they don't divide the work up so that each is responsible for something. To make sure that each learner experienced the whole process, I reminded them frequently to use their checklists. They seemed to forget that.*

Another pre-service teacher also explains how she accommodated the principle of individual accountability in co-operative learning when she facilitated learning:

Pre-service teacher C: *Two of the groups have done good research on the problem. They have divided the research amongst themselves and each member had to report back to the group on their part of the research.*

Interviewer: *Did they themselves decide to divide the research work between one another?*

Pre-service teacher C: *No, I told them … Facilitated rather … to do that, because I wanted them to work co-operatively.*

In her log-book, one pre-service teacher reported that one of the all-boys groups, also referred to in Section 5.3.3 Sub-code 4.1, socialised too much and did not take up their responsibility to co-operate to solve the problem. This was an all-boys schools, thus all the groups consisted of boys only. Her other groups however, were progressing at a satisfactory rate. She writes the following:

> *"Week 3: I told the one group that they had to pull up their socks, because they still had a lot of work ahead. I asked them several times now to pay more attention to their work. Maybe I should have broken this group up and placed them with a well functioning group. The other groups pulled their weight. Sometimes they had conflict, especially when it came to the making of the energy device. Those were good, healthy arguments".*

Sub-code 4.4: Quality of learning

To fully report on the quality of learning which occurred as a result of the PBL strategy, the quantitative data also need to be considered. This will be done in detail when the findings are discussed in the last chapter.

In the interview one pre-service teacher concluded that "we *didn't realise that it was such hard work to do our own research and to plan the whole thing on our own".* This response by a pre-service teacher correlates with the empirical data and comments made by learners from the experimental group. In Section 5.2.5, 79% of the learners indicated that they had to work very hard to execute the PBL task. In the qualitative comments, learners requested more time to engage in the PBL task. Another pre-service teacher said that she even had to consult professors in the Department of Biochemistry to discuss information she needed to solve the problem. These results are indicators of the pre-service teachers' and learners' active involvement in the problem-solving process, which is a premise for effective knowledge construction. The post-test results also showed that PBL learners performed significantly better in some questions which were formulated on the higher cognitive levels according to Bloom's taxonomy (See Section 5.2.2). Another pre-service teacher mentioned that "*some of the learners said that they have really learnt something and that it was fun".*

In the last two days the final solutions to the technological problem had to be presented to a delegation from the Department of Minerals and Energy, as was promised in the initial problem statement. Of all 26 groups only one group did not do a final presentation. One pre-service teacher wrote in her log-book that she was very satisfied with the presentations.

- *I decided to invite their real teacher to attend their presentations. She could at least see that I did not waste her kids' time.*

- *Lynette's (fake name) group made the best presentation. They made a TV programme to introduce their product to the world. Different interviews were conducted with the research team to highlight the advantages* and disadvantages of their design.

Another pre-service teacher wrote in brackets in her log-book that *"the gas burner was better than some of our solutions "*. It should be remembered that the pre-service teachers and the grade 10 learners were exposed to exactly the same problem.

The same pre-service teacher who consulted the Department of Biochemistry, mentions that her creative thinking abilities were challenged by PBL. It must be kept in mind that this pre-service teacher, like the others, had already completed her pre-graduate Baccalareus in Sciences degree. As previously indicated she explains the following:

- *At the beginning of the year I could not think creatively at all because it was never necessary to be creative. Your approach has challenged me to develop my creative thinking to such an extent that I can think diverse about problems and solutions.*

Finally, the PBL experiences have impacted more than her learning only, but her person as well. She says that *"I have personally grown and I believe so have my fellow students"*.

Results on Code 5: Pre-service teachers' perceptions of outcomes-based education after the PBL training and practice experience

Table 5.13: Code 5: Pre-service teachers' perceptions of outcomes-based education after the PBL training and practice experience.

Code 5:	**Pre-service teachers' perceptions of outcomes-based education after the PBL training and practice experience.**
Interview question: Technology education was implemented within an OBE framework. What impressions of OBE have you gained through this training and practice experience?	
Code 5.1:	OBE as problem-based methodology, drawing on research, using a variety of resources
Code 5.2:	The difference between OBE and the transmission model (traditional teaching)
Code 5.3:	Outcomes are more than textbook content

In this interview question, the pre-service teachers seem to focus their perceptions of OBE on teaching strategies as they manifest in classroom practice, and not on the principles, philosophy and systems associated with OBE.

Sub-code 5.1: OBE as problem-based methodology, drawing on research, using a variety of resources

Four of the six pre-service teachers felt that technology education can be taught effectively through a PBL model. One of them said that PBL is a good example of what OBE strategies can look like when implemented in practice. The comments which follow, emphasise elements of the learner-centred approach associated with OBE. It also indicates that pre-service teachers realise that technology has a problem-based nature and will therefore be taught more effectively through strategies which enhances active learner involvement and problem-solving. The pre-service teachers made the following remarks in this regard:

Pre-service teacher C: *I don't think technology education can be taught in a different way than the method which you have used.*

Interviewer: *Explain more.*

Pre-service teacher C: *Finding solutions to problems, is something that cannot be given – the individual has to look for it by doing thorough research. Doing your own research under the guidance of a facilitator is OBE methodology, isn't it?*

Pre-service teacher E: *I don't' think you can teach technology in another way, than this way. If you give them problems and research to do, that is OBE. OBE is about taking them out of the classroom away from one textbook to the real life outside – like I did with the coal mine fieldtrip.*

Pre-service teacher D: *I think this training in technology education has given me a good idea of how to teach in an OBE way.*

Interviewer: *What ideas did you get?*

Pre-service teacher D: *How to prepare and design problems which may help learners to demonstrate a specific outcome in technology.*

Pre-service teacher E: *How to look for resources for a resource kit and how to plan co-operative group work.*

- **Pre-service teacher F:** How to plan integrated learning tasks.

- **Pre-service teacher B:** Doing your own research under the guidance of a facilitator is OBE methodology, isn't it?

Although pre-service teachers touched on issues related to OBE, especially classroom practice, they seem to have a narrow view of OBE in terms of the place of direct instruction in OBE. They seem to think that direct instruction has no place in OBE. Maybe the interview question should have been rephrased to communicate the idea that they should give their

understandings of OBE in its broadest sense. The pre-service teachers communicated their understanding of OBE within the narrow context of technology education only, which might be expected because that is what they experienced.

Sub-code 5.2: The difference between OBE and the transmission model (traditional teaching)

One of the pre-service teachers actually contrasts the active learner participation with the passive, receptive role of the learners in the traditional class. The principle of challenge is also contrasted with the idea of imitating and executing experiments in a recipe like fashion.

- *Well, in technology education, like in science education, learners preferably have to discover and explore on their own. In technology education they have to design and make their own ideas –they are not given a design to just copy and make. It seems to me that is what OBE is all about in practice.*

- *These learners had to analyse their own information from the kit and other books and the internet. The other class received notes and lessons with all the information. They were given the experiments and exactly how to do it. They actually only had to follow the prescribed instructions. That's the difference between OBE and the other method.*

Three of the pre-service teachers mentioned the idea that OBE implies a new role for teachers towards becoming facilitators of learning, which goes beyond transmitting knowledge.

- *I know that I am a facilitator who is not supposed to transfer, sometimes I felt like doing it.*

In the final chapter when all the results are integrated, more will be said about how learners acted out their role as facilitators in the classroom context. At this stage, it seems that this is one of the areas in which pre-service teachers had a narrow view which needs to be broadened in a future training programme.

Sub-code 5.3: Outcomes are more than textbook content

The pre-service teachers referred to as A and B, often referred to the concept of processes and skills as some of the outcomes for technology education. The interview with the two pre-service teachers acknowledges the fact that they view outcomes to be more than memorising and recalling the textbook information:

Pre-service teacher A: *I think that I understand now that outcomes are more than facts and textbook content. In technology one of the outcomes is the problem-solving process which learners need everyday in their lives. Outcomes can also be the skills which B has referred to in his explanation of technology.*

Pre-service teacher B: *And I think we showed the science teachers in this school a good example of OBE methods.*

Interviewer: *What are the OBE methods?*

Pre-service teacher B: *No lessons, where teachers transfer information, but problems and co-operative work where learners look for their own info.*

This last comment by "B" also confirms a narrow view of OBE teaching strategies. It seems that the idea of direct instruction, when necessary, has no place in this teachers' repertoire of teaching strategies.

5.3.4 General conclusion: Qualitative results

The pre- and post-training results elicited the pre-service teachers' perceptions and experiences on technology education, PBL, OBE and the inter-relationship between them. These results obtained from the pre-service teachers, will be correlated with the quantitative and qualitative results obtained from the learners. All the results will be merged and reflected upon to get a holistic picture of the research and its main findings.

5.4 Summary

The first section of this chapter presented the quantitative data obtained through empirical methods from the learners. The results of the pre-, post- and attitude questionnaire were presented and briefly discussed. Comments made by learners from the experimental group were selected as a means of gaining some level of insight into the reasons behind certain empirical results. The second section of the chapter focused on the qualitative results from the pre-service teachers. Their pre- and post-training and practice understandings and experiences were analysed, coded and presented in a narrative format.

The last chapter will discuss the collective results emanating from this research in detail. The research questions will be revisited to determine to what extent they have been answered. The final step will be to make recommendations for future interventions and research in this field.