AN INVESTIGATION INTO THE EFFECTS OF CO-OPERATIVE LEARNING STRATEGIES ON THE TEST RESULTS OF SCIENCE STUDENTS AT N3 LEVEL AT THE PORT ELIZABETH COLLEGE FOR FURTHER EDUCATION AND TRAINING

By

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ABSTRACT

The poor academic performance of Engineering Science N3 students at the Port Elizabeth College for Further Education and Training prompted me to conduct this study. The aim thereof was to investigate the influence that a co-operative learning strategy would have on the test results of students who enrolled for this programme. The hypothesis being tested in this study was whether co-operative learning strategies would improve the test results of science students in the N3 Engineering Science class.

A literature review on co-operative learning, its principles as well as the role of the lecturer as facilitator was conducted. In addition, the different types of co-operative learning techniques were investigated so that an approach conducive to the needs of students studying at Further Education and Training Colleges could be selected. The Student Team Achievement Divisions (STAD) technique was deemed to be the most suitable approach.

Both qualitative and quantitative data gathering techniques are employed in this study. Interviews were carried out with fellow lecturers at the Port Elizabeth College to determine what teaching strategies are generally implemented in the N3 class.

Experimental research involving two groups of 30 students was then conducted to determine the results of students. The one group (experimental) was subjected to an intervention, namely the STAD co-operative learning technique while the other group (control) was taught using the traditional method of talk and chalk. This intervention took place over a period of

two weeks. However, prior to the co-operative learning intervention and before students were divided into groups, they were taught as a single group for a period of two weeks. The total time spent on this experiment was therefore four weeks.

Student test scores gathered from the experiment was statistically analysed and reported on in chapter five. These results indicated that the experimental group out-performed the control group by a significant margin. The higher academic achievement of students in the experimental group could only be attributed to the alternative teaching strategy (STAD) which was absent in the teaching of the control group. This proved the hypothesis.

CHAPTER ONE

INTRODUCTION AND OVERVIEW

"Research extends knowledge by venturing into areas of which very little is known or filling the gaps of existing knowledge"

(Behr, 1983, p.4)

1.1 INTRODUCTION AND BACKGROUND TO THE STUDY

After the abolishment of apartheid in 1994, South Africa (SA) moved from a non-democratic to a democratic state. The inequalities experienced by those who were forced to study under an inferior education system, needed to be addressed. Professor Kader Asmal as Minister of Education stated that "Apartheid has left a legacy of poverty and inequality which put severe constraints on what can be achieved" (DoE, 2003, p.viii). According to the South African Science and Technology Indicators (SASTI) (1996), 81% of all South African pupils at the time of democratisation were students from previously disadvantaged communities. Our education system was in serious need of transformation.

In the process of transforming our education system, SA adopted an outcomes based approach to education. "Outcomes Based Education (OBE) is a learner-centred, results orientated design, based on the belief that all individuals can learn" (DoE, 1997, p.17). According to Van Der Horst and McDonald (1997), OBE firstly focuses on the desired end results called outcomes, and secondly, on the instructive and learning processes employed to guide students toward the end results. Hence teaching methodologies have become student-centred with a strong emphasis on group work.

The Port Elizabeth College (PEC) is a Further Education and Training (FET) college. In this and all other FET Colleges, OBE has not been implemented yet. The curriculum and syllabi are predominantly based on external examinations written every trimester. The syllabus was originally designed to cater for apprentices who attended the College for a period of three-month's theoretical tuition. Until the outdated curricula, used by FET Colleges, have been amended to make it conducive to OBE, it will be difficult for lecturers to move away from traditional teaching methods. Despite these handicaps, a small number of lecturers have attempted to use group work as a teaching method.

The Engineering Science N3 examination results for November 2003 show that only 36% of students at PEC passed their examination while the National pass rate was 40%. The PEC's figures correspond with student's term marks, which they achieved in tests written throughout the trimester. The under-preparedness of the student entering the College could be attributed to factors such as under-qualified teachers, teacher/learner truancies, and poor quality teaching. At the College lecturers blame this under-preparedness for the dismal results. The researcher feels that co-operative teaching, when successfully implemented, could help to improve the N3 science results. In the past limited success was achieved when learners worked in groups. This study focuses on the effect of changing the teaching style to create a learning environment that is more student-centred.

1.2 RESEARCH QUESTION

The following research question addresses the problem:

Can the implementation of co-operative learning strategies in the N3 science class of the Port Elizabeth College for Further Education and Training influence the science test results?

The main question is answered by addressing three sub-questions, namely,

- What teaching strategies are generally implemented in the N3 class?
- How can co-operative learning strategies be successfully implemented?
- How do the results of students exposed to co-operative learning strategies compare with the results of students who are not exposed to co-operative learning strategies?

1.3 THE FORMULATED HYPOTHESIS

Co-operative learning strategies will improve the test results of science learners in the N3 class.

1.4 THE DELIMITATION OF THE RESEARCH

This study is confined to the PEC for Further Education and Training, Russell Road Campus, a government institution, which specialises in vocational training. The targeted group of learners will be students who enrolled for the N3 science programme in 2004. All other students are excluded from this investigation.

The researcher will use an experienced colleague, who teaches N3 science, to assist in carrying out this study. Only the lecturer's teaching style, which could be considered traditional, will be observed. Hence, the lecturer's personality will not be considered in this research.

In order to limit extraneous variables such as the classroom environment, learning content, lecturing time etc. that could influence the study, the data was gathered over four weeks. For this reason only two sections of the science syllabus will be focused on in this study namely, Linear Motion and Moments.

1.5 THE SIGNIFICANCE OF THE RESEARCH

Because of poor achievements in science amongst students at PEC and other secondary schools, the researcher feels that research into improving the N3 science results of students at the PEC would be beneficial to various parties. Firstly, the students could benefit due to increased success and success breeds confidence, self-esteem and motivation. Secondly, parents could benefit. If the failure rate is reduced there is less financial strain on them.

Thirdly, the PEC could benefit because success will mean an increased through-put rate in these subjects. Students passing through the system successfully will in future determine the amount of financial subsidy an institution will receive from the state. Fourthly, secondary schools and other institutions as well as the country as a whole could benefit, if the results of this study show that this teaching methodology improved students performances. Lastly, students who fail mathematics and science at secondary schools will continue to be in abundance until the didactical shortcomings of teachers, in the field of mathematics and science at schools, are addressed. If this study proved to be successful then co-operative teaching can be included in future staff development programmes at Secondary schools and FET Colleges.

1.6 THE ASSUMPTIONS

The researcher has been teaching N3 science students for twelve years and through lengthy observations and personal experience has identified certain assumptions that form the basis of this research. The first assumption is that students coming from disadvantaged secondary schools had under-qualified teachers for the mathematics and science subjects. They need to be assisted to improve their performance in science. The second assumption is that these students are mainly second language learners with Afrikaans or Xhosa being their mother

tongue. This will be taken into account when discussion occurs in the groups. The third assumption is that students want to improve on their previous performances in science. It is expected that they will be willing to participate in the research.

1.7 DEFINITION OF CONCEPTS

Disadvantaged students are students who may come from a low socio-economic background experiencing language and/or cultural differences (Ruff, cited in Johnson, Johnson & Holubec, 1993).

N3 students are learners studying at Further Education and Training colleges in South Africa with the equivalent level of standard 10, now grade 12 (SASTI, 1996, p.22).

In ***co-operative learning strategies*** students work together and are responsible for one another's learning as well as for their own learning (Johnson, Johnson & Smith, 1991; Schniedewind & Davidson, 1987). "Co-operative learning is a successful teaching strategy in which small teams, each with students of different levels of ability, use a variety of learning activities to improve their understanding of a subject" (Balkcom, 1992, p.1).

1.8 THE LITERATURE REVIEW

A review of a number of sites on the Internet, as well as various other literature resources, illustrates that extensive research on co-operative learning as a successful teaching strategy has been undertaken. However, Felder (1995, p.1) stated that apart from one-shot trials very few studies on co-operative teaching in engineering classes have been conducted. Furthermore, most available literature refers to studies undertaken in the United States of America (USA). The researcher will interpret and adapt these writings to accommodate

conditions within SA. Research into co-operative learning strategies in SA is limited to educational conference papers as well as occasional articles in educational journals (Penlington & Stoker, 1998).

This study will try to establish how co-operative learning works at a FET College. Felder (1994) cites Johnson, Johnson and Smith's work to show that co-operative learning situations are successful when there is a positive interdependence amongst student goal achievements. Students must perceive that they can reach the learning goals if and only if, the other students in the learning group reach their goals. Stahl (1994, p.2), further reinforced this argument, by stating that students must either swim together or sink together. Therefore students need to depend on one another for their personal, teammate's and group's success in mastering the learning content and attributed skills (Stahl, 1994, p.2). Furthermore, Lewin cited in Davies (1976) maintained that groups tend to generate more and better ideas and group members are more likely to accept the outcome when it is discussed in a group. Situations where learners are haphazardly divided into groups created opportunities for students to relax and play. These laissez-faire groups, where less work is done and more time is spent on horseplay and idle talk, should be avoided (Davies, 1976). According to Jacobs and Gawe (1996), for co-operative learning to take place students must use their imagination and creativity and successfully demonstrate their ability to teach their sections of the work effectively to other members within the group. The researcher feels that by allowing students to work in well-organised and controlled groups, their social capabilities such as communication, as well as a sense of sharing, tolerance and acceptability of differences will be enhanced. Johnson *et al.* cited in Felder (1996, p.5) reinforce this by stating that students who learn co-operatively generally achieve higher grades. This is the focus of this study.

1.9 THE RESEARCH DESIGN

Being a science lecturer, the researcher adopted a positivistic approach to solving the problem that resulted in students obtaining poor results. Improving the examination results of N3 science students in a teacher centred environment showed little success. Positivism is a scientific approach based on measurable evidence and is characterised by varying levels of generalisability (Allison, O'sullivan, Owen, Rice, Rothwell & Saunders, 1996). It is a paradigm traditionally adopted by natural science researchers as they pursue tests that could be measured quantitatively. Allison *et al*. (1996, p.8), state that "positivistic research frequently draws upon measurable evidence and is referred to as quantitative".

However, this research falls within both a qualitative and quantitative paradigm. Sub-questions one and two lend themselves to exploratory and interpretive research, which falls within a qualitative approach. The researcher will make use of student group diaries and interviews to collect data. In sub-questions one the lecturers at the college will be the primary source, with the researcher making use of historical methods to determine and report on teaching methods previously used, as well as describing the existing teaching methodology. According to Allison *et al.* (1996, p.13) "if the event being studied is within living memory, the primary sources might include the testimony of people able to be classed as reliable eye and ear witnesses".

Information obtained from a suitable literature study will be used when implementing co-operative teaching in sub-question two. When deciding on how learning strategies should be implemented, this method should yield the most reliable results.

Sub-question three requires experimental research of a qualitative and quantitative nature. Experimental research also falls within the parameters of the positivist's paradigm and can be

used to test the hypothesis by comparing performance tests statistically. Blaxter, Hughes and Tight (1996) confirm this by stating that experiments are at the heart of what is known as the scientific method and that a well formulated hypotheses can be tested via carefully designed and controlled tests. According to Leedy (2001, p.300), “true experimental designs offer a greater degree of control and refinement and a greater insurance of internal and external validity”. Internal validity illustrates the degree to which the independent variable influenced the experiment whereas external validity determines how generalisable to result of the experiment is. That is, can the results of the experiment be successfully engaged in similar cases and have the same effect?

Leary cited in Blaxter *et al.* (1996), argues that a well designed experiment entails the following three properties namely:

- an independent variable that can be manipulated in order to assess its effects on human behaviour
- the power to assign subjects to various experimental conditions
- the ability to control extraneous variables that can influence individual behaviour

The independent variable in this case is the teaching method. As the researcher and lecturer I was able to create the two groups to be used for the two different methods of teaching. As far as possible an effort was made to create two groups of students who had similar academic and communicative abilities. The choice of the sample will be discussed in chapter three.

Qualitative data will be collected by observation and interviews while quantitative data will be gathered from the test marks. The data will be analysed both qualitatively and quantitatively.

1.10 OUTLINE OF STUDY

Chapter one of this study provides a framework in which the research will be performed. It also serves as an introduction to the research question and its sub-questions. In addition, it outlines the literature review to a limited extent and the research approaches that will be employed.

Chapter two reflects an extensive literature review. Firstly, instructional paradigms which promote co-operative learning as a teaching strategy are discussed. Then the different schools of instruction are highlighted. Thereafter, the principles of co-operative learning are described. Lastly, the role of the lecturer as facilitator in a co-operative environment is looked at.

Chapter three provides a synopsis for the different types of research approaches and explains how they are conducted and integrated. Because this study falls within a qualitative and quantitative paradigm, both these approaches are investigated. Furthermore, the true experimental and ex post facto research designs are described.

Chapter four explains the data collection process and analysis of sub-question one and two and in chapter five the data for sub-question three are analysed and reported on. In chapter six conclusions are drawn and recommendations are made.

CHAPTER TWO

LITERATURE REVIEW

"What children can do together today, they can do alone tomorrow"

(Vygotsky in Johnson *et al*, 1991, p.19)

2.1 INTRODUCTION

Ellen and Rosseel (cited in Messerschmidt, 2003) observed that the innovative migration from content based learning to an outcome-driven, learning-centred approach would help SA compete against countries at various levels of society including education. Outcomes based education (OBE) was therefore gradually implemented at schools via the introduction of Curriculum 2005 (Messerschmidt, 2003). The next stage was that FET Colleges needed to implement an OBE approach, which endorses group work as a cornerstone of co-operative learning.

This chapter focuses on various aspects of co-operative learning. Firstly, an instructional paradigm is determined in which co-operative learning strategies are explored. Next, the different schools of thought regarding co-operative learning are explained. Then, the focus falls on the principles of co-operative learning, the different co-operative learning strategies (group working techniques), as well as group structures and sizes. The types of groups are explained with a justification of the choice for this study. Lastly, the roles of the lecturer and the students subjected to co-operative learning will be examined.

2.2 INSTRUCTIONAL PARADIGM

Group work forms one of the cornerstones of co-operative learning which therefore places it within the paradigm of constructivism. Messerschmidt (2003, p.107), refers to the work of Masithela and Steyn defining constructivist theory as follows, “learners co-construct shared meanings within a process of negotiation and even conflict through mainly language engagement”. In line with this statement, Scott, Dyson and Garter, (in Van Loggerenberg-Hattingh, 2003), postulate that hands-on activity and inquiry-based learning are constituents of a constructivist approach to education. According to Roblyer, Edwards and Havriluk, (in Conwa, 1997, p.2), constructivists encourage students to solve real-life practical problems co-operatively in working groups. Co-operative learning therefore encapsulates the idea that all members in a group learn and assimilate the same content (Jacobs & Gawe, 1996).

An Important concept within the constructivist approach is to guide the student from what s/he presently knows to what is to be known (Murphy, 1997, p.3). Guiding a student from the known to the unknown according to Murphy (1997) is known as ‘scaffolding’. “Scaffolding allows students to perform tasks that would normally be beyond their ability without the assistance and guidance from the teacher” (Murphy, 1997, p.3). Scaffolding is regarded as an important feature used by constructivists to improve the problem solving skills of students.

Murphy (1997, p.3) refers to Vygotsky’s work where student’s problem solving skills are characterised by three categories namely:

- Skills that are possible to perform
- Skills that are not possible to perform
- Skills that are possible to perform with help from an external factor.

When placing students into groups, which will allow them to work co-operatively together towards a common goal, it is necessary to integrate students who have the necessary skills to solve problems with those who do not. Thus the skills of students, who exhibit shortcomings in the fields of problem solving, communication and interaction, may be developed.

Van Loggerenberg-Hattingh (2003, p.52), reinforces the above argument by quoting John Dewey's observation that "true learning is based on discovery guided by mentoring rather than the transmission of knowledge". Co-operative learning encourages a student-centred approach to tuition and changes the role of the teacher from being the bearer of all knowledge to being a facilitator that participates in proceedings. Jacobs and Gawe (1996, p.3) explain that "knowledge is the construction of the individual student, and that this construction depends on each individual's perception of the reality that impacts on his/her sensory organs". Constructivists acknowledge the impact of prior learning on future interpretations made by students concerning the learning content (Van Loggerenberg-Hattingh, 2003, p.52).

Mkhabela (1994) brings another facet into the discussion on co-operative learning when she cites Slavin's belief that learning within a co-operative environment is enhanced when learners are rewarded. Nevertheless Mkhabela (1994), states that it remains to be seen whether black students will co-operate without extrinsic rewards. This will not be addressed in this study. The extrinsic motivation for both the participants and the researcher will be the improvement of test marks.

In considering the implementation of co-operative learning Slabbert (1992, p.439), claims that "people unfamiliar with co-operative learning often mistake it for group work". By merely dividing students into groups does not necessarily mean that all the students are co-operating with each other to solve a problem or complete a task. Situations where students are

haphazardly divided into groups that present an opportunity to relax and play must be avoided. Laissez-faire groups, where less work is done and more time is spent on horseplay and idle talk, should be avoided (Davies, 1976). Slabbert (1992) referring to Davidson states that special attention must be paid to the various aspects of group work to ensure that participating members of the group are in fact learning. As a paradigm, constructivism promotes co-operative learning.

2.3 DIFFERENT SCHOOLS OF INSTRUCTION

According to Kagan (1992), there are three main schools of thought on co-operative learning, namely:

- The structural approach
- Learning together
- Curriculum specific packages

2.3.1 THE STRUCTURAL APPROACH

The structural approach is characterised by the systematic design of co-operative learning. According to Kagan (1992), structures are seen as the building blocks of lessons with a content-free way of organising the interactions between students in the classroom. Structures have predictable outcomes in the academic, linguistic, cognitive and social domains. Those in favour of this method of learning believe that quality learning can occur without special curriculum materials.

2.3.2 LEARNING TOGETHER

Kagan (1992) sees learning together as a framework in which co-operative learning in any subject area or grade level can function. Furthermore, Kagan (1992) stresses that every

lesson is characterised by group work with specified academic and social-skills objectives that must be reached. Positive interdependence, face to face interaction, individual accountability, interpersonal skills and group processing are deemed fundamental to the success of this approach (Kagan, 1992; Jacobs, 1999). These principles will be further explored later in this chapter.

2.3.3 CURRICULUM SPECIFIC PACKAGES

"Packages are one or more structures combined with curriculum materials specially designed for co-operative learning" (Kagan, 1992, p.10). This approach is considered to be content-bound. There is evidence that developing packages resulted in substantial curriculum development (Kagan, 1992). Curriculum Specific Packages represent a task-reward structure that motivates students in the learning process.

It does not matter which school of thought is adhered to because the methodologies all depend on the principles of co-operative learning to be successful.

2.4 PRINCIPLES OF CO-OPERATIVE LEARNING

Six principles are outlined as essential criteria for the success of co-operative learning. Slabbert (1992) specifies the following principles as essential credentials when implementing co-operating learning:

- Positive interdependence
- Individual accountability
- Promotive (face to face) interaction

- Co-operative skills
- Evaluation/group processing
- Group size

Johnson and Johnson (in Davidson, 1990) endorse five of the above-mentioned elements as important for co-operative learning strategies. They however do not include group size. Nevertheless, the researcher will explore this principle because it is believed that group size can have an effect on the success of a group involved in co-operative learning.

According to Johnson *et al.* (1991), for co-operative learning situations to be successful it is necessary to have a *positive interdependence* amongst students. Shulman, Lotan and Whitcomb (1998, p.5) refer to Johnson and Johnson's statement that "positive interdependence is the essence of collaboration". Interdependence is enhanced when all members of a group are enticed to deliver either verbally or practically towards producing a product or solving a problem. "To implement positive interdependence of goals, roles, resources and rewards, students must believe that they are linked to others in a way that one cannot succeed unless the other members of the group succeeds and vice versa" (Johnson *et al.*, 1991, p.16).

Davidson (1990) refers to Johnson and Johnson's argument that no individual can be successful without the success of his/her fellow group members to endorse this principle. Common goals and rewards for group achievements can be a catalyst for

success. Stahl (1994, p.1), also reinforces Johnson and Johnson's views, by suggesting that lecturers should structure learning tasks to promote the interdependence of students. Participating members of groups must willingly express themselves and contribute towards solving problems or completing end products successfully. Students must realise that being

dependent on one another is a matter of either swimming together or sinking together (Johnson *et al*., 1991).

However, Davidson (1990) explains that students must be made aware that they cannot hitch-hike on the work of others and that each individual will be held accountable to complete his/her section of the work. It is of fundamental importance that each learner accepts responsibility for his/her own learning. Stahl (1994, p.3) underpins this argument by emphasising that "each learner must be held individually responsible and accountable for doing his/her own share of the work and for learning what has been targeted to learn". Students must be made aware that they are ultimately accountable for the achievement of the learning outcomes (Huetinck & Munshin, 2000).

Lecturers can ensure *individual accountability* by randomly requesting any student at any time throughout the lesson to give comments to his/her peers on the activities, which are being discussed. Furthermore, if individually written tests are employed students will realise that they cannot ride on the back of fellow students within the group. Students will become aware that they are responsible for their own learning and the effort made by each individual determines his/her results. Johnson *et al*. (1991, p.19), refer to Vygotsky's statement that "what children can do together today, they can do alone tomorrow".

According to Johnson *et al.* (1991), the chain reaction between positive interdependence and *promotive interaction* results in individuals freely encouraging and facilitating each other's efforts to reach the group's goal. Therefore, everyone's input is important for the successful completion of the task. However, lecturers must avoid high-status students from dominating the interactions causing low-status students to drop out of group activities, become disruptive or to sit quietly without participating (Shulman *et al.*, 1998). Shulman *et al.* (1998), believe that

students regarded as smart and popular (i.e., high-status students) work harder in groups than students who are weaker in the subject (i.e., low-status students).

Furthermore, Shulman *et al.* (1998) argue that unless these status-performance issues of students are addressed the gap between respective students can increase. It is therefore of paramount importance to advance promotive personal interaction (i.e., face to face interaction) between members of a group. Promotive interaction according to Johnson and Johnson (in Davidson, 1982) includes assisting and encouraging others within the group to achieve. Furthermore, Johnson *et al.* (1991) conceded that promotive interaction enhances the willingness of students to help each other, exchange resources and provide each other with constructive responses.

In order to achieve promotive interaction, certain *co-operative skills* need to be used. Johnson *et al.* (1991), specify the following criteria for effective interpersonal and small group skills:

- Students need to know each other
- Students need to build a relationship of trust
- Students need to communicate clearly, accurately and effectively
- Students need to accept and support each other
- Students need to resolve conflicts in a mature constructive manner

According to Johnson *et al.* (1991), people are not naturally born with skills to interact, but social skills are acquired through effective teaching. They claim that the more lecturers emphasise and reward social skills the higher the achievements from co-operating groups will be.

Group processing is a fundamental feature, which requires members of a group to reflect on how well the group is functioning. At the end of the group work session, the lecturer must provide time for students to identify actions that were helpful and those that hindered the

group from functioning smoothly. The members must generate alternatives that will restore the momentum and accelerate the group towards the achievement of the set goals. Johnson *et al.* (1991), further found that groups consisting of high, medium and low achievers subjected to the concept of 'co-operative-with-group-processing' achieved higher grades than groups who were not exposed to this process.

The effectiveness of group work will depend on the *size of group*. Group sizes, may vary between two and six members. According to Rice cited in Jaques (1991, p.19), "six is a critical number for groups in all situations". Jacques (1991) argues that characteristics of a group change as the size of the group increases and once the group size increases to beyond twelve, face to face interaction is considerably reduced. Jacques (1991), specifies that groups with less than six members have difficulty in expressing their feelings about the group because of the close proximity of members. Slavin (1990), disagrees with Jaques in that he recommends that groups be restricted to four members. Kagan (1992), recommends that group sizes should be restricted to an even number of four or six as this will allow members of a group to be able to work in pairs. It also avoids the 'odd man out' effect. In this study, because of restricted classroom floor space the groups had six members, which is an even number and can be divided into pairs.

Johnson *et al.* (1991) postulated that research clearly indicated that co-operation, when compared with competitive and individualistic efforts, resulted in the following:

- Higher achievement and greater productivity
- More caring, supportive and committed relationships
- Greater psychological health, social competence and self-esteem

Davies (1976) echoes these sentiments by remarking that the general products of the groups are far more superior to individual efforts. Davies (1976) quotes Wheeler's view that, "the

presence of others has a profound effect on the norms, standards, values and behaviour of individuals". This is echoed in the Department of Education documents, "knowledge is not neutral, but is underpinned by the collective vision, mission, values and principles of people" (DoE, 2003, p.ix).

Working as a team, being able to think critically, being able to solve problems and to communicate are generic skills for workers at all levels of society (DoE, 2003). Appropriate group working projects and assignments that promote interaction between students are of paramount importance. Students must familiarise themselves and frequently use skills such as decision making, trust building, communication and conflict control to develop their confidence within small groups (Johnson & Johnson cited in Davidson, 1990). Therefore, tasks must be structured in a way that will promote group-working skills and encourage students to work together co-operatively (Jacobs and Gawe, 1996; Schniedewind & Davidson, 1987). This will allow the student to demonstrate his/her ability to competently function within a team, a non-negotiable characteristic of adulthood.

2.5 TYPES OF CO-OPERATIVE GROUPS

According to Cowie, Smith, Boulton and Laver (1994), effective student learning takes place in a social context and from primary school days learners work around tables in small groups. They refer to Vygotsky's claims that "there are clear benefits when more knowledgeable peers or adults interact with a less expert child and that learning is about negotiation rather than transmission" (1994, p.44). Many co-operative methods of instruction involving group work have been developed. In the following sub-sections five such methods will be discussed.

2.5.1 STUDENT TEAM ACHIEVEMENT DIVISIONS (STAD)

This method of co-operative learning was pioneered by Slavin who predicted that when students of different social and ethnic backgrounds work together towards a common goal social interactions will be more positive (Cowie *et al.*, 1994). They also state that "STAD groupings were deliberately heterogeneous, mixed by ability, race and gender" (1994, p.54). Furthermore, they explain that the lecturer presents a lesson whereafter students are divided into groups of four to five students mandated with the task of mastering worksheets, provided by the lecturer. Slavin (1990, p.3) confirms the above views by stating that "the lecturer first presents the lesson and then the students work within their teams to make sure that all team members have mastered the lesson". If students are individually assessed, individual accountability will be promoted. The individual scores of team members are added, and the sum thereof will reflect the score achieved by the group or team. Cowie *et al.* (1994) believe that the team with the highest score should be rewarded.

2.5.2 TEAM GAMES TOURNAMENT (TGT)

Slavin (1990) postulates that Team Games Tournament (TGT) has the same dynamics as STAD but adds a dimension of excitement. Slavin (1990), explains that team mates help each other to prepare for a tournament. However when the games start the participating team member cannot be assisted by other members of the group resulting in individual accountability being effected. Cowie *et al.* (1994), refer to the work of De Vries and Slavin to show that this approach is characterised by heterogeneous groups consisting of four to five members per group. Members work together collaboratively to solve a problem or master a section of the learning material. Thereafter students question one another to establish the degree to which the relevant material has been learned. Cowie *et al.* (1994), explain that a representative of each group will be randomly selected to compete in a tournament similar to a quiz against fellow class members in other teams. Points scored for individual contributions

will be accumulated and the total number of points will represent the success of the team. Thereafter, the team with the highest score will be rewarded.

2.5.3 TEAM ASSISTED INDIVIDUALISATION (TAI)

Potgieter (2003, p.20) refers to Slavin's statement that "this method requires a specific set of instructional materials and involves members working on different units depending on their proficiency in the subject". Slavin (1982), further states that team members continue at their own pace, helping each other with problems that arise. However, final testing is undertaken without any help to ensure individual accountability.

2.5.4 JIGSAW

This approach is characterised by two groups, namely the home group and the expert groups. The home group is mandated with the task of building a puzzle from the information individual members gathered within the structures of their expert group. Firstly, students are divided into home groups where the learning material is divided into four or five sections so that each member of the home group is mandated with a certain section of the learning content (Cowie *et al.*, 1994; Jacobs, 1999). The students are then rearranged into expert groups according to the section of the learning material that they collaboratively need to investigate. After extensive discussions and mastering their section of the work, students return to their home groups to teach their content specifics to their team members. The sections of learning content are then put together to complete the puzzle, hence the name 'jigsaw'. "Jigsaw is a good method of building a positive sense of interdependence within the group as well as a sense of individual accountability" (Cowie *et al*., 1994, p.54).

2.5.5 GROUP INVESTIGATION

Sharan and Sharan developed this approach to group working and it is seen as the most complex of the co-operative learning strategies (Cowie *et al.*, 1994). Students select sub-topics within a general area determined by the lecturer and organise themselves into groups of two to six members. Students collaboratively identify problems, collect data relevant to their plan, examine and analyse findings critically, after which they prepare a report on the work. Each group in turn will present his/her section of the learning content to the class, who in turn, with the help of the lecturer, will evaluate their presentation (Cowie *et al.*, 1994). A mark will be allocated to each of the teams and the team with the highest score will be rewarded.
In this investigation, the researcher decided to employ the STAD approach to co-operative learning. STAD is considered to be the most appropriate method because participating students are representative of a diversity of cultural, ethnic and racial groups. Furthermore, STAD characterises the presenting of a lesson and thereafter the collaborative discussion of the learning content in groups. This is especially suitable because the researcher is under considerable pressure to complete the N3 Science syllabus within a period of ten weeks. Students, when placed in co-operative groups do not have sufficient time to enter into extensive time consuming debates. In conclusion, STAD promotes the gaining of knowledge as well as enhancing interracial relations between students, both of which are outcomes of co-operative learning.

2.6 SOUTH AFRICAN STUDIES ON CO-OPERATIVE LEARNING

An extensive literature review conducted by the researcher revealed that very little research on co-operative learning has been conducted in SA. Investigations at FET Colleges are virtually non-existent. Felder (1995, p.1), reinforces the researcher's findings by stating that apart from one-shot trials very few studies on co-operative teaching in engineering classes

have been conducted. However, the researcher found two studies involving co-operative learning. These were Potgieter (2003), who conducted a study investigating the influence of co-operative learning on the test results of pre-technician students at the Port Elizabeth Technikon and Mkhabela (1994), who investigated the effect co-operative learning would have on the academic performance of black South African university students.

Employing 'jigsaw groups' as a co-operative learning strategy, Potgieter (2003) proved that co-operative learning positively affected the test results of students. Students subjected to group work showed substantial improvement in their test results compared to students who were taught traditionally. Furthermore, an experiment by Mkhabela (1994, pp.108-111), involving students working in co-operative dyads using scripted co-operative learning strategies showed favourable results in three of the five hypotheses tested. However, there were mixed results from hypotheses that tested the academic performances of students. Some results showed that students who were subjected to scripted co-operative learning strategies out-performed students, who were learning individually, while in order cases the individual students out-performed those who were involved in scripted co-operative learning.

2.7 THE ROLE OF THE LECTURER

With the implementation of OBE, a paradigm shift from traditional teaching to an approach that empowered the student to manage his/her own learning occurred. Co-operative learning forms one of the cornerstones of OBE and sees the traditional teaching role changing to that of a facilitator. Potgieter (2003, p.30) quotes Crabill's explanation that "in the co-operative classroom the teacher is no longer required to fill the role of an expert or purveyor of all knowledge, rigidly adhering to only one stifling method of instruction".

Shulman *et al.* (1998) endorse this argument by stating that the lecturer is no longer the focal point around which activities rotate or the sole provider of information. Instead, it is expected of the lecturer to fulfil the role of a facilitator who manages and controls the learning process in an organised manner. However, facilitating is a difficult role to perform by the traditional teacher and according to Jaques (1991, p.124) requires "careful listening and eliciting rather than giving one's own knowledge". According to Johnson *et al.* (1991), the following errands could simplify an already complex learning strategy for the lecturer.

2.7.1 SPECIFYING THE OBJECTIVES

Johnson *et al.* (1991), identify two objectives that lecturers need to consider. The first is the long term ***academic objective*** which allows students to become critical thinkers and adept problem solvers (Johnson *et al.*, 1991). The second is the ***social skill objectives*** detailing personal and small group skills required by learners to effectively participate in the lesson (Johnson *et al.*, 1991).

2.7.2 LECTURER DECISIONS BEFORE INSTRUCTION BEGINS

The lecturer is obliged to make certain decisions regarding the implementation of co-operative learning groups. Examples of such decisions as suggested by Johnson *et al.* (1991) are listed below:

- ***Group size*** should be between two and six members. According to Rice cited in Jaques (1991, p.19), "six is a critical number for groups in all situations". However, Johnson *et al.* (1991), as well as many other experts on this subject claim that groups should be restricted to four members.
- ***Arranging the classroom*** to allow students to be in close proximity to each other as this promotes direct eye contact and comfort in sharing of resources. However, the lecturer

should have easy access to any individual member. The groups should be far enough apart so that they do not interfere with each other's learning. According to Majeed, Fraser and Aldridge, (2001, p. 6), "Changing the actual classroom environment in ways that make it more congruent with that preferred by the class is likely to enhance student outcomes".

- ***Planning instructional materials*** to promote interdependence. A single copy of the learning material to each group will ensure material interdependence. By arranging materials into puzzles and providing each member of the group with one section of the puzzle guarantees the dependence of students on information from their fellow team members (Johnson *et al.*, 1991). By structuring material into a competition format such as team game tournaments, will promote a perception of interdependence between team members (Johnson *et al.*, 1991).
- ***Assigning roles*** that complement or interconnect students can be employed to secure interdependence between members of a group (Johnson *et al.*, 1991). An example of this would be a summariser restating the group's major conclusions and answers while a checker ensures that all group members can explain the work. The role of an accuracy coach would be to correct the mistakes in other member's explanations. The lecturer would be facilitating the proceedings, guiding the groups to their destination with appropriate interventions where and when necessary.

2.7.3 STRUCTURING THE ACADEMIC TASK AND POSITIVE INTERDEPENDENCE

In structuring the ***academic task***, a lecturer needs to focus on specific activities. These activities which are discussed in the following paragraphs aim to develop positive interdependence. Johnson *et al.* (1991) maintain that when the lecturer **explains the academic task** to the students, several aspects need to be considered. Firstly, set the task so that the students are clear about the assignment. Secondly, the objectives of the lesson as

well as the task at hand need to be related to the student's past experience and knowledge. Thirdly, provide students with examples and explain the procedure required for completing the task. Lastly, check if students understand the assignment by asking relevant questions.

The lecturer needs to **explain the criteria** that will be used to evaluate learner performance. These criteria should also help lecturers determine if the group goals as well as the end goal of the whole class has been reached. Inform the students about the criteria for success and which behaviour the lecturer expects to observe while the students are actively participating within groups (Johnson & Johnson cited in Davidson, 1990).

Lecturers must structure tasks that will **promote positive interdependence** among members of a group. Davidson (1990) claims that lecturers should afford students the time to grapple with problems, search for strategies and evaluate their solutions, thereby placing the primary focus on the student's own thinking process. Each member of the group must therefore realise the importance of actively contributing towards achieving the goals set by the group (Johnson & Johnson, in Davidson, 1990).

Felder (1996, p.5), stresses that although students need to depend on each other to complete the task, individuals need to produce their share of the work. Therefore, it is important that lecturers equip students with the basic skills to participate productively within a co-operative environment. This activity involves **structuring individual accountability**. Each individual must learn the assigned material to be used to complete assignments. This can be realised if the lecturer randomly chooses a student to present his/her work piece to the class.

Interaction between groups will have a positive effect in promoting the outcomes of co-operative learning throughout the whole class. By **structuring co-operation among groups**

members of a group who have completed their assignment can compare answers and strategies with other groups who have also completed their tasks (Johnson *et al.*, 1991).

2.7.4 MONITORING AND INTERVENING

Once the students start working, the duty of the lecturer is to move around in the classroom and observe the activities. By continuous observation the lecturer can obtain a window into students minds and establish the degree of their comprehension (Johnson *et al., 1991).* Johnson, Johnson and Holubec (1993), state that when students co-operatively interact, hidden thinking processes become overt and a cognizant observer will make inroads into the student's understanding of the assigned material.

"Lecturers monitoring the learning process should clarify instructions, review important procedures and strategies, answer questions and teach skills related to the task when necessary" (Johnson *et al.*, 1991, p.68). When the lecturer, while observing the activities, discovers individuals who are not participating because of inadequate social skills, s/he must intervene. Furthermore, Johnson *et al.* (1991, p. 68), recommend that "instructors should not intervene any more than is absolutely necessary".

2.7.5 EVALUATING LEARNING AND PROCESSING INTERACTION

Lessons may end with an evaluation or processing activity. In *providing closure to the lesson* students are required to summarise what they have learned as well as visualise where it will fit into future lessons. Lecturers may use the opportunity to summarise major points or answer final questions (Johnson *et al.*, 1991).

In trying to *Process how well the group functioned,* lecturers are obliged to interpret their observations to the group. Group members can spend a little time grappling with how they

functioned as a group. After receiving feedback from the lecturer, students can reflect on the quality of their co-operation and improve where necessary (Johnson *et al.*, 1991).

2.8 SUMMARY

Co-operative learning is an innovative learning strategy extensively applied within the USA. However, the different instructional approaches can be adapted to cater for a country characterised by diversity. The benefits that go along with employing a co-operative learning strategy mandated with essential elements like positive interdependence, face to face interaction, individual accountability and the use of collaborative social skills are beyond question. Some of the benefits that students are likely to experience are: 1) higher academic achievement, 2) better inter-cultural and ethnic relations and possible long lasting inter-cultural friendships, 3) respect for other human beings and their shortcomings, 4) reduced conflict between different racial groups and 5) improve motivation as a result of newly found success.

The lecturer's role changes to that of a facilitator managing the group working processes, guiding learners in the right direction and intervening when necessary. In this research, the role of the researcher will be that of lecturer. I will use the principles of co-operative learning in implementing a new teaching strategy. The details of the implementation will form part of the research design reported on, in chapter three.

CHAPTER THREE

RESEARCH DESIGN

"Progress is relative and can therefore be measured by noting the degree of change between what was and what is"

(Leedy, 1997, p.229)

3.1 INTRODUCTION

This chapter focuses on describing the various research methodologies that have influenced the investigation and the analysis of this study. Behr (1983) argues that employing a single investigating method cannot efficiently complete a research project. Therefore, a combination of methods from a number of research paradigms will be explored. For this study an experimental inquiry is seen as the most appropriate approach in determining whether co-operative learning positively affects the test results of N3 science students. According to Leedy (1997), an experimental study statistically investigates the possible relationship between different phenomena. The analyses include the processing of numerical data, which falls within the boundaries of a quantitative approach.

When deciding on how learning strategies should be implemented, interpreting information gathered from a suitable literature study is the most reliable source. The most appropriate research methodology to determine and report on teaching methods previously used, as well as describing the current teaching methodology is the explorative approach. Descriptive, explorative and interpretive research methodologies illustrate the qualitative nature of an inquiry.

3.2 QUANTITATIVE AND QUALITATIVE RESEARCH

In their search for knowledge, researchers rely on information, which can be gathered by making use of various instruments designed to cater for different methodological approaches. According to Leedy (1997), every research study employs its own unique way of collecting, analysing and interpreting data whether it is of a qualitative or a quantitative nature. Blaxter, Hughes and Tight (1996), postulate that many scientific inquiries fall within both a quantitative and qualitative approach to research.

Cresswell's (1994) views on ***quantitative research*** reflect that natural science researchers use variables, which lend themselves to a numerical measure, statistical analyses and interpretations. The information collected using any of these methods are then used to determine whether certain predictions about generalisations hold true (Leedy, 1997). Best and Kahn (in Blaxter *et al.*,1996) concretise Leedy's theory by suggesting that a well planned quantitative approach can provide data for numerical analysis and interpretation and therefore highlights its nature as positivistic. However, in the effort to make unbiased, universal and context-free generalisations, the researcher must adopt a method that will ensure objectivity when the variables of interest are measured (Leedy, 1997). He further asserts that a fundamental prerequisite for objectivity in a quantitative study is for the researcher to remain detached from his/her subjects. In this study the same tests were given to both the experimental and control groups. The groups were formed as objectively as possible. The composition of the groups will be discussed later in this chapter.

On the other hand, Best and Kahn state that ***qualitative research*** describes events and persons scientifically without the use of numerical data (Blaxter *et al*., 1996).

According to Leedy (1997, p.105), “qualitative researchers collect an extensive amount of verbal data from a smaller number of participants and present their findings in the form of words and descriptions that are intended to accurately reflect the situation under study”. Best and Kahn reinforce this view by stating that qualitative researchers are more open and responsive to their subjects and tend to focus on exploring as much detail as possible (Blaxter *et al.*, 1996). Leedy (1997, p.106), stages that the qualitative researcher may interact with his/her subjects. As a result, through this interaction, variables and theories may develop or emerge which can be used to explain the phenomena. This is however, stressful, time consuming and hard work (Blaxter *et al.*, 1996).

As this study is located in both the quantitative and qualitative fields and in itself falls within different paradigms of inquiry, the study makes it necessary then to investigate the paradigms appropriate for this scenario.

3.3 INTERPRETIVIST PARADIGM

Interpretivism is characterised by standpoint epistemology. “Standpoint epistemologists reject standard good social scientific methodologies because they produce people as objects” (Denzil & Lincoln, 1998, p.188). According to Behr (1983), the interpretivists will start their enquiry and data collection by observing the social world, unnoticed by others, at their own pace and on their own terms with unstructured interviews and natural conversation. He claims that data collected could be seen as subjective, internal, qualitative and unique.

Potgieter (2003) refers to the work of Burrel and Morgan to explain that people are empowered and have the freedom as human beings to create their own knowledge. In line with the above the researcher will encourage students to freely involve themselves in

constructive dialogue and in so doing acquire as much knowledge as humanly possible. With knowledge comes power to critically distinguish between right and wrong. According to Denzil and Lincoln (1998), standpoint epistemologists are closely related to the critical and constructivist paradigms. In this study the only link to the critical paradigm will be a focus on the acceptance of diverse cultures. Co-operative learning requires that the student's social background and experience is considered. In this study the STAD method did not focus too strongly on the past experiences of the learners but on how the learners internalised the lectures. Hence ontologically the study favoured the constructivist paradigm.

3.4 POSITIVIST PARADIGM

Positivism is a philosophical system recognising only facts and observable phenomena in the world. It is rigidly scientific and focuses on objectivity as a framework for its decisions. According to Allison, O'Sullivan, Owen, Rice, Rothwell and Saunders (1996), the primary goal of scientific research is one of description, prediction and explanation which may lead to laws, that is, "consistencies or patterns in properties or behaviour are formulated into descriptive laws which can then be used predictively" (Allison *et al*., 1996, p.7). In line with this Burrel and Morgan in (Potgieter, 2003) state that man is completely subjected to his/her environment and that knowledge can only be acquired in the presence of descriptive laws.

In the process of their investigations, true positivists rely heavily on numerical data from which statistical analyses may be forthcoming. The quantitative approach to research can thus be seen as fundamental to the positivist's approach. Leedy (1997), confirms this by stating that "Quantitative research is sometimes referred to as the traditional, the positivist, the experimental or the empiricist approach to investigating a problem" (1997, p.104). It is

therefore inevitable that true positivists rely heavily on numerical data that can be statistically analysed in order to test hypotheses, make generalisations or make predictions about future phenomena.

3.5 EXPERIMENTAL RESEARCH

Blaxter *et al*. (1996) explain that the most popular research method associated with the subject Physical Science is that of experimentation. They claim that experiments are at the heart of scientific research. According to Allison *et al*. (1996), experimental research seeks to answer the question 'what if'? They describe an experiment as the introduction of a new element (variable) in an old situation and the observation of the effect thereon. This supports Leedy's (1997) argument that an experimental study focuses on keeping the 'what was' constant and influencing the 'what is' by introducing extraneous variables and monitoring the changes, if any. Blaxter *et al.* (1996) explain that experimentalists manipulate variables in order to influence a specific situation either negatively or positively. While there are many types of experimentation, of which some are indicated in the next paragraph, they are all dependent on manipulating certain activities.

3.6 TYPES OF EXPERIMENTATION

Campbell and Stanley (in Leedy, 1997), categorise experimental studies into four general types namely:

- Pre-experimental designs
- True experimental designs
- Quasi-experimental designs
- Ex-post facto designs

All four types will be described in order to justify why a particular one was chosen as suitable for this study.

3.6.1 PRE-EXPERIMENTAL DESIGN

Schumacher and McMillan (1993) imply that pre-experimental research designs are problematic when threats to the internal validity of an experiment need to be controlled. Furthermore, they state that the results of research based on this approach are usually uninterpretable, as causal inferences are difficult to make. They suggest that pre-experimental research is best used as a way of generating ideas that can be tested more systematically at a later stage (Schumacher & McMillan, 1993).

Leedy, (1997, p.233) states that although the pre-experimental design is “simple to carry out, its results are relatively meaningless”. Since I firmly believe that something must be done to improve the results of N3 Science students I needed to ensure that my results were not “meaningless”.

3.6.2 TRUE EXPERIMENTAL DESIGN

According to Schumacher and McMillan (1993), to neutralise any differences that might exist between subjects, true experimentalists use random sampling to allocate subjects to various groups. They also argue that the true experimental design characterises the manipulation of the experimental variables in order to determine if any changes occurred as a result of this manipulation. Pretest-post-test control group designs, pretest-post-test comparison group designs and post-test only control group designs are approaches that exhibit the criteria set by true experimental research. These designs are commonly employed within the fields of biological and physical sciences (Schumacher & McMillan, 1993).

3.6.3 QUASI-EXPERIMENTAL DESIGN

When random sampling to experimental and control groups are not possible the quasi-experimental design comes to the fore and can be used as a successful methodology (Schumacher & McMillan, 1993). Furthermore, they claim that quasi-experimental designs are not true experiments however, they do have limited control over threats to some sources of invalidity.

3.6.4 EX POST FACTO DESIGN

Ex post facto research concerns the investigation of possible cause-and-effect relationships through observing a current state of affairs and back-tracking to find possible causative factors (Behr, 1983). Behr also argues that many instances occur where "teasing out of possible antecedents of events that have happened" does not lend itself to be manipulated by the inquirer (1983, p.90). Schumacher and McMillan (1993) elaborate by saying that ex post facto research investigates relationship after they have occurred, focusing on what happened differently for comparable groups rather than manipulating a current condition. However, the latter can also be seen as a non-experimental technique as the focus falls on the phenomena after the experiment has taken place. Leedy (1997, p.238), supports Schumacher and McMillan's view by observing that "ex post facto designs has little that is experimental about it".

In contrast Schumacher and McMillan (1993, p.316), argue that "true experimental designs provide the strongest, most convincing arguments of the causal effect of the independent variable because they control, for the most, sources of internal invalidity". Leedy (1997) confirms this by stating that true experimental designs offer a greater degree of control and refinement as well as greater insurance for internal and external validity.

My study began with an anlaysis of the Science examination results of N3 Engineering students over the past three years at the PEC. I tried to look back to find a possible cause of such poor results but decided to go further. I was determined to change the results for the future. Although my study may have originated in ex post facto design within the larger convenient sample the two groups were formed by matching. It is these arguments that persuaded me to employ a positivist approach between that of true experimentation and ex post facto design. My study looks at the test results in terms of a teaching methodology and is thus not grounded in the physical science per se.

3.7 CONSTITUENTS OF A CLASSICAL EXPERIMENT

According to Allison *et al.* (1996), the designing of a classic experiment entails the dividing of subjects into two matched groups. These groups are to be equal in all respects. Leedy (1997, p.229), concurs with this by stating that “each group must resemble the other on as many characteristics as possible, especially those that are critical to the experiment”. One group (experimental group) will be subjected to the experimental variable, hence the name experimental group, while the other group will function under normal conditions, hence the name control group. Leedy (1997) states that the ‘control group-experimental group’ designs are common to an experimentalist’s approach of searching for knowledge.

The extraneous influence in this study was to manipulate the classroom situation by introducing an alternative method of instruction and recording the results thereof. Blaxter *et al.* (1996), suggest that artificial situations in which variables are manipulated should be created. Allison *et al.* (1996), by arguing that in experimental research some variables are controlled or kept constant while others are manipulated, verifies this. These researchers concede that there are two variables associated with experimental studies namely the independent variable and the dependent variable. The independent variable is

manipulated (i.e. subjected to the experimental treatment) while the dependent variable could be affected by the intervention.

In this study the researcher also employed two groups a control group and an experimental group. A change in the teaching methods of the experimental group was orchestrated. The teaching method was therefore the independent variable also known as the experimental treatment. The dependent variable was the test results.

3.8 METHODOLOGY

This study is aligned with the principle of Blaxter *et al.* (1996) that education research inquires often necessitate the use of more than one specific investigating approach. Therefore, to answer the research question, different methodologies need to be employed when examining the following three sub-questions.

- **Sub-question one:** *What teaching strategies are implemented in the N3 class?*

Sub-question one lends itself to explorative research which falls within the interpretive paradigm of a qualitative approach. Qualitative research is non-experimental. The researcher in association with his science lecturing colleagues will form the primary source of information.

- **Sub-question two:** *How can co-operative learning strategies be successfully implemented?*

Sub-question two requires interpretive research of a descriptive nature. Information obtained from a literature review in chapter two was used to determine how co-operative learning can be effectively implemented. Elements of co-operative learning were then

implemented with the experimental group. The methodology of co-operative learning therefore formed the experimental variable.

- **Sub-question three:** *How do the results of students exposed to co-operative learning strategies compare with students who are not exposed to co-operative learning strategies?*

In order to answer this question, the researcher employed an approach more closely aligned with true experimentation. True experimentation requires subjects to be divided into two equivalent groups namely an experimental group and a control group. Although Behr (1983) claims that the subjects must match in all respects, he also states that exact equivalence is virtually impossible.

The control group was isolated from the experimental variable influence, namely a co-operative learning strategy. The experimental group was subjected to a co-operative learning strategy. After completing the experiment, both groups were subjected to a written performance test and the results thereof recorded.

3.9 CHOOSING THE SAMPLE

During the first stage of this study, 60 students were conveniently incorporated to form a single class. The researcher had no control over the students that were selected as students were enrolled at the PEC on a 'first-come-first-served' basis. This is in line with convenience sampling also known as non-probability sampling. According to Blaxter *et al.* (1996) non-probability sampling like the convenience method is appropriate in the absence of a sampling framework for the population in question. After being subjected to the first of two tests the 60 students were divided into two heterogeneous groups.

The marks of the 60 students were arranged from the highest to the lowest and students were placed alternatively in each of the groups. This can be seen as a form of random sampling, also known as probability sampling, as each individual had an equal chance of getting into either of the two groups (Blaxter *et al.*, 1996). More details of the actual composition of the groups are provided in the next chapter. The final test results of both groups were used to determine the statistical data required to answer sub-question three of this study.

3.10 SUMMARY

Research design gives investigators the opportunity to explore a variety of methodologies with which they can engage, in their search for knowledge. This study, based on multiple approaches, describes the qualitative and quantitative nature in which it is conducted. Furthermore, special attention is devoted to the positivist and interpretivist paradigms which are underwriters to the research methodologies employed. A possible resolution to the principal research question (viz., *Can the implementation of co-operative learning strategies in the N3 science class of the Port Elizabeth College for Further Education and Training influence the science test results?)* entails experimentation. This resulted in scrutinising various experimenting techniques and the adoption of one that suited this study.

In the following chapter the actual ***data collection*** activity will be focused on. Furthermore, the techniques used to gather the data will also be discussed.

CHAPTER FOUR

DATA COLLECTION AND ANALYSIS

"The wealth and quality of data gathered strongly depends on research skills and encouraging comments made at the correct time"

(Bless & Higson-Smith, 1995, p.110)

4.1 INTRODUCTION

This chapter incorporates the collection of data required to complete this study successfully. This can only be achieved with the construction and application of a mechanism that will aid in obtaining the required information. Mounton (2001) emphasises the necessity of measuring instruments to collect data. It is therefore inevitable that the researcher will employ various data gathering techniques suitable for the different research methodologies used in this study.

In order to answer the research sub-questions it was necessary to undertake a literature review to develop the experimental variable. The effects of this variable were determined through performance tests, interviews and student group diaries. Data collected for sub-questions one and two are described and analysed in this chapter.

4.2 ESSENTIALS OF DATA COLLECTION

Schumacher and McMillan (1993) emphasise that validity and reliability are two very important issues when determining the quality of an investigation. They argue that the

quality of a measurement used in a study determines the nature of its results. Weak or biased measurements result in weak or biased outcomes. On the other hand “strong measures increase confidence that the findings are accurate” (Schumacher & McMillan, 1993, p.223).

To ensure validity of the quantitative data necessary to answer sub-question three of this study (viz., *How do the results of students exposed to co-operative learning strategies compare with students who are not exposed to co-operative learning strategies compare with students who are not exposed to co-operative learning strategies?)* a neutral lecturer was solicited to draw up a test question paper based on the same content matter taught in both groups. This lecturer was asked to mark the test-scripts of both groups. To avoid any chance of marks being manipulated the answer scripts of both groups were integrated into one set before marking began.

Schumacher and McMillan (1993) imply that standardising all factors that can possibly influence the results of a study and therefore its validity is essential. Furthermore, all other variables (e.g. times of classes, the consistency of possible distractions, carefully screening of learning material to ensure that it is the same new content for both groups etc.) that could affect the results of this study were considered. Both experimental and control groups were accommodated in classrooms on the second floor of the Garnham building. Both groups used the same textbook and a handout, consisting of past examination question papers, was supplied to each of the sixty students participating in the study. Therefore the only difference between the groups was the method in which they were taught.

A detailed description of the information that was obtained will be forthcoming. The information generated to pilot a solution to each sub-question of this investigation will be presented individually in the sub-sections to follow.

4.3 DETERMINING CURRENT TEACHING METHODOLOGIES

Sub-question one: *What teaching strategies are implemented in the N3 class?*

To answer sub-question one the researcher conducted ***non-scheduled structured interviews***, with four colleagues who have experience in teaching Engineering Science N3. Bless and Higson-Smith (1995) explained that the non-scheduled structured interview is an interviewing method whereby a phenomenon is established using pre-determined questions. This is in line with using a historical approach to determine the teaching strategies used in the past.

The following questions were asked in the interviews:

- How would you go about teaching Moments?
- What teaching strategy/style do you use?
- Why do you use this teaching method?

In the interview the researcher chose ‘Moments’ as the topic of discussion as this section of the syllabus was to be taught during the employment of the co-operative learning strategy. Furthermore, past experiences have proven that ‘Moments’ are also one of the more difficult sections in the syllabus for students to understand.

The first three questions were asked to two of the interviewees during the interview. They mentioned that the time factor restricted them from exploring alternative teaching

methodologies. This resulted in a fourth question for the interviews of the other two candidates. The fourth question was *"What role does time constraint play in the teaching approach you use"?*

In addition, the researcher relied on information obtained from his own personal experiences as well as that of other colleagues through informal discussion. Leedy (1997) suggests that the bulk of the data obtained during qualitative research originates from the researchers themselves as a direct result of their personal involvement. Adding to this Bless & Higson-Smith imply that "the most frequently used method of gathering information is by directly asking respondents to express their views" (1995, p.105). These techniques were used in the interviews conducted in this study.

4.3.1 THE LECTURERS

Four male lecturers who teach Engineering Science at the PEC Russell Road Campus (RRC) were interviewed to determine the teaching style they apply in their classroom. Lecturer A has eight years teaching experience and has been teaching Engineering Science for three years. Lecturer B has 20 years teaching experience during which he taught Engineering Science. Lecturer C has 13 years teaching experience and has been teaching Engineering Science for all this time. Lecturer X has 16 years teaching experience and has been teaching Engineering Science for five of these years. Lecturer B and C were interviewed together as they were close friends and in order to present them with an opportunity to reveal more in-depth information about the teaching strategies they employed in their classrooms.

4.3.2 THE DATA

Responses to question one and two of the interview are linked to **teaching methodology.** These will be analysed together. Lecturer C showed evidence of using a teacher-centred approach to teaching. He said "*I always take the point of departure that they know nothing".* He went further to say that *"you have to explain to them what equilibriums are all about".* He indicated that he demonstrated the concepts himself. When asked "What strategy do you use?" he answered, *"Well mostly talk and chalk on the board".*

Lecturer B. also used this teacher-centred approach. Although he mentioned that he sometimes allowed his students to discover for themselves, he also said that *"all the concepts needed to be explained to the students".*

Lecturer A on the other hand showed his preference for co-operative learning. *"I mix the style a little bit, but I'm more for the co-operative style because the students understand each other better. They have ways to talk together. They understand their own language so I just give them a problem and I say you are free to discuss this, you don't have to do it on your own and then they will discuss and come up with answers. Sometimes you'll find that they will come with the same answer, but with different approaches, because they do it differently".*

He also indicated that using the co-operative approach has resulted in an improvement in his student's test results. He said that he had resorted to co-operative teaching when he found that the traditional way of teaching had bad results. When he changed his teaching style he said the *"there was some improvement".*

Time constraint was the most common excuse for using the talk and chalk teacher-centred approach to learning. Lecturer C stated that *"ten, eleven weeks to finish the syllabus, some work is very intricate, complicated and it takes a while to explain. Some of the chapters are quite lengthy and it takes days, sometimes weeks to complete one particular module".* Furthermore, Lecturer C claimed that *"with semesters we had more time to do the same work".* Lecturer B reacted as follows, "*yes, the time barrier also plays a role because it does not always allow you to work effectively in groups".* Lecturer A also responded as follows *"trimesters are a bit hectic because everyone is in a rush. What you do today, you may not do tomorrow to determine if learning took place the previous day, because you're running out of time. With semesters there is ample time so semesters are better than trimesters".* Although all three lecturers assumed that it would be better to have semesters rather than trimesters this was not the case. There has always been a trimester system.

4.3.3 THE ANALYSIS

From the comments of the three lecturers it can be seen that two of them employed the traditional teacher-centred approach to teaching 'Moments'. It seems as if they simply passed on the information to the students. Their reasons for their choice of method were that there was not enough time to allow for student's interaction. Although the third lecturer had changed to co-operative learning he also complained of a lack of time. He preferred the system of semesters but the reality was that they had to work in a trimester cycle.

Interviewee number four, Lecturer X, also participated in the implementation process described further on. He used the teacher-centred approach and his responses will be analysed under the control groups. In effect 75% of the sample of lecturers interviewed at the College employed the traditional method of "chalk-and-talk".

4.4 TEACHING METHODOLOGY EMPLOYED IN THIS STUDY

Sub-question two (viz., *How can co-operative learning strategies be successfully implemented?)* is answered in three parts. The first part involved an extensive literature review of co-operative learning strategies. This is reported in chapter two.

From the literature review the *Student Team Achievement Divisions (STAD)* method was chosen as the co-operative learning strategy for the experimental group. A description of how the experimental and control groups were formed as well as the sampling styles used to justify these, follows. The last part describes how co-operative learning was implemented in my classroom.

A characteristic of the STAD method is that the lecturer first explains the subject content to the students. Thereafter, the class is divided into five groups consisting of six members each. The students are seated in such a way that face to face interaction is enhanced. The students are given enough personal space within the group structure to feel comfortable and have access to each other and the working material. They are close enough to each other so that they can communicate without disturbing the rest of the class. Group members are encouraged to work collaboratively within their groups.

Furthermore, individual groups are spaced far enough apart so that the lecturer as facilitator has access to any member of a group at any time without hindrance. There is enough floor space between the groups so that distractions, resulting from in-group collaborations, are minimized. The positioning of the groups should also allow for cross-pollination of ideas, solutions and arguments as group member's move freely between groups in order to confer and/or share resources.

4.4.1 CREATING A CONTROL AND EXPERIMENTAL GROUP

Firstly a *control and experimental group,* consisting of 30 heterogeneously mixed students had to be created. The first 60 students who enrolled for the N3 engineering science programme were used to participate in the study. The principle of “first come first served” resulted in a convenience sampling being used for the complete sample of the control and experimental groups. According to Leedy (1997, p.204), convenient sampling is a type of non-probability sampling in which “the researcher has no way of forecasting, estimating or guaranteeing that each element in the population will be represented in the sample”. In this study the researcher had no control over the selection of candidates who participated or the physical environment from which they originated. Nevertheless, the students did represent the larger demographics of the Nelson Mandela Metropole in terms of race, gender and cultural groups. The academic and communicative abilities of the students were the only unknown factors.

In order to validate the experimental and control groups in terms of ability, the researcher subjected the 60 participating students to a written performance pre-test which was used to randomly ‘place’ the students in one of the two groups. Leedy (1997) states that randomness is a critical element and should be carefully considered when a post-test only approach is applied. The pre-test used in this study served as a method of placement. This test was carried out after a certain amount of teaching had taken place. In this instance, an experienced colleague (lecturer X) taught a section of the syllabus over a period of two weeks. Thereafter, the students wrote a performance test of which the results were recorded from the highest to lowest marks obtained. Correspondingly, the test scripts were numbered from one to sixty with the highest mark allocated to the first position and the lowest mark to the sixtieth position. All the even numbers formed the *experimental* group while all the odd numbers were placed in the *control* group. This meant that the two groups

had a greater chance of being academically balanced, thereby ensuring that the internal threat of selection is not a factor when interpreting the results. In every pair the odd numbered student obtained a higher or equal mark to the even numbered student. Hence it was expected that the median mark for the pre-test of the control group was higher than that of the experimental group.

4.4.2 THE IMPLEMENTATION

Lecturer X taught the **control group** using the traditional method of chalk and talk which is a characteristic of teacher-centred teaching. In the interview lecturer X said that he made drawings to assist the interpretation of calculations on the chalk board. He used the traditional method as he was concerned with the time allocated to complete the work. He remarked as follows, "*there are a lot of time constraints, you have to finish the syllabus in a certain period of time".* He also indicated that he was not convinced that group work was necessary. Below are three reasons why he did not opt for group work:

- *They have to write exams on their own so they should work on their own in class*
- *Classes are too large*
- *Classroom arrangements do not allow for groups to be formed*

Even when the class size was reduced to 30 students for the second part of this research project lecturer X continued to teach as he had done previously, using the teacher-centred approach.

I began by introducing myself to the students in the ***experimental group.*** I used ten minutes of the period to explain to them that they were to participate in an experiment where a different teaching method was to be used. I informed them that they were going to work collaboratively in groups and that I expected them to participate within the groups. Furthermore, I emphasised that each individual was still responsible for his/her own

learning and that “free riders” will not be tolerated. They were told that within the groups all opinions counted equally.

Initially there seemed to be reluctance amongst students. However, this quickly changed when I explained to them about the advantages and benefits associated with a co-operative learning environment. Those students who were not keen to participate in groups were given the option to join the class where the students were taught traditionally. However, no one left the class.

I then divided the class into five sub-groups with equal ability and as heterogeneously as possible with regard to the other factors such as race and gender. The five-sub-groups consisted of six students each. To form the groups the pre-test marks of these students were again arranged from the highest to the lowest. These marks were allocated numbers from one to five. After the fifth mark I repeated the one to five and this process continued until the thirtieth mark was allocated a five. I then placed all the ones in group one, all the two’s in group two and so on until group five. This is in line with Rumsey’s observation that “some type of randomisation scheme for assigning groups works best since isolation of students and clique-formation are controlled” (1998, p.6).

Group one comprised five black males and one black female student (Average mark = 42.17). *Group two* comprised four black males one coloured male and one white male student (Average mark = 41.89) while *group three* had four black males, one black female and one white male student (Average mark = 40.74). *Group four* comprised four black males, one black female and one coloured male student (Average mark = 39.32) and *group five* comprised five black males and one black female student (Average mark = 38.83).

After the groups were created and their leaders chosen I taught a lesson on ‘Moments’. Although many of the students in the group had completed Science at N2 level, I still decided to determine their background knowledge or lack thereof. I asked questions like *“what do you understand by the term ‘Moment’?”* With very little responses forthcoming, I concluded that the best place to start would be at the beginning.

I used a model of a basic lever system with the fulcrum at its centre in equilibrium. By applying a force directly opposite the fulcrum I showed the students that the lever did not turn. I then suspended the lever (in equilibrium) in the air by means of an elastic band and again applied a force directly opposite the fulcrum. This time the elastic band was stretched downwards and when the force was removed the lever returned to its original position. This example was used to explain Newton’s Third Law which states that for every action there is an opposite and equal reaction (De Villiers, 1998; Getliffe, nd; Van Rensburg & Van Rooyen, 1983). *(Upward forces equal downward forces if the applied downward force that stretched the elastic band is equal to the force required to bring the lever to its original position.)*

Using the same model in a balanced state *(In equilibrium),* I placed a mass on the right hand side of the fulcrum, which caused the lever to turn in a clockwise direction. Then I placed a mass with equal magnitude and distance on the left-hand side of the fulcrum and the lever returned to equilibrium. On removing the mass on the right hand side of the lever, the lever turned in an anti-clockwise direction and replacing the mass brought the lever back to equilibrium. This was in accordance with the Law of Moments as this law states that the sum of clockwise moments equals the sum of anti-clockwise moments about the same turning point (Moolman, 1995; Moolman, 1996; Baragwanath & Olivier, 1987).

Once the students understood these concepts and no further questions were forthcoming, I did an example on the chalkboard, which required the implementation of the above laws.

A second example explaining how forces act on a lamina was also conducted. At this stage the students were asked to explain the concept of the sum of clockwise and the sum of anti-clockwise moments about certain points on the lamina. By doing this I demonstrated that by changing the position of the fulcrum, a clockwise moment can change to an anti-clockwise moment and vice versa. This approach where the lecturer first explains the work to the class and then allows them to work in groups is in line with the characteristics of a STAD co-operative approach.

When all the explanations were completed and student questions answered, I presented each group with a hand-out consisting of two problems that needed to be solved. Groups one and two did problem one while groups three, four and five did problem two. After five minutes of group work I realised that things were not going as planned. Some students were working on their own while others were trying to work together. I intervened by halting all proceedings. I explained to the students that this was not an individual exercise but a group effort. Furthermore, I told them that I wanted them to find solutions to the problems by working together. I requested that they put their writing pads away and issued each group with a large blank sheet of white paper on which they had to complete their work. I also informed them that any member of the group would have to explain their solution to the class.

The interdependence created by the single sheet of paper definitely improved interaction between group members. The classroom became a beehive of activity as personal interaction increased. I moved amongst the groups to ensure that the students stayed on track with the work they had to do and only intervened when they asked for help. I verbally encouraged silent members to participate and continuously reminded them that each member of the group had to be able to solve the problems and only then could they deem themselves successful. After completing the problems (forty-five minutes later) I requested

a member of group one to give feedback on the chalkboard on how their group approached the problem. Thereafter I inquired from the rest of the class if they were in agreement with the solution that was put forward on the chalk board. A member of group three was asked to explain the solution of problem two. This solution was incorrectly done. The members of group four were asked to correct the solution.

At the end of the period I spent five minutes reflecting on the group working activities and requested the students to come up with ideas on how these activities could be improved. By their replies I tried to establish their feeling towards this new method of learning. Student remarks showed that the majority of them enjoyed their first day of co-operative learning in the science class. They requested that we use co-operative group work on a more regular basis. I asked each group to keep a diary in which they could write down their honest opinions of their experiences in a co-operative environment (Notes had to be made on a daily basis).

To ensure individual accountability I asked the class to do two problems from the exercise at home. Furthermore I informed them that the problems for homework would be looked at, within their groups, during the first ten minutes of the science period the following day.

The next day I decided to promote student interdependence and provided each group member with a specific task to perform. For instance, one member of a group would read the problem from the textbook while a peer would take down all the given information. The third member would select the appropriate formula to solve the problem while someone else would convert the given information into its correct form. The fifth member would do the calculation on his/her calculator leaving the last person to give comments to the rest of the class on their accomplished work. However, it was emphasised that the actual solution to the problem must be achieved via interaction between group members.

By the third day groups were starting to gel and compete against one another in a race to determine who would be first to solve problems. Interventions into their activities became less frequent as the experiment continued. A stage was reached where, if a group had a problem, the leader of the group would approach the other groups for help, and only if help were not forthcoming would s/he turn to me for help.

Student confidence was growing because difficult problems were now being attempted and these resulted in student debates. The less active students began to participate in activities. Requests that co-operative group work be done on a more regular basis cemented the impression that this exercise was successful. The final issue which laid all doubts to rest regarding co-operative learning as a teaching strategy for college students was when break time arrived and students were still busy debating the solutions within their groups. This evidence convinced me that the students were enjoying the challenge put before them. I came to this conclusion because in a traditional atmosphere students would have already packed up and been ready to leave well before it was time to do so.

4.4.3 COMMENTS FROM STUDENTS

During the experiment I sensed a feeling of enjoyment amongst students as members of different races and gender freely interacted to find solutions to problems. Students with lesser ability became more confident as interactions continued. This resulted directly from improved participation in student debates. I did not experience this spirit amongst students when I observed them being taught by lecturer X in the previous section.

The following comments taken from student group diaries indicated that co-operative teaching was appreciated by most of them and that they wanted to continue using this approach.

“We think it is cool, all of us think so and would like to do it in all the chapters”.

"All of us have made up our minds and we want to stay in groups".

"Our group did not understand Moments but now it is clear to them. Everybody communicated in the group".

"The guys are more talkative. They are much more enthusiastic about doing class work, they are more awake".

"We think group work in class was a good idea because we understand the work better. We are looking forward to the next test".

One of the group members said, he did not like group work, but *"the group work of yesterday helped me".*

From the above comments, it appears that students enjoyed working in groups. Their self-confidence seemed to have grown as some students were looking forward to their next test. Students, on their own admission, were more talkative. They were more enthusiastic about the subject and said that they would like to continue in groups for the remaining chapters. The students even confessed that they were more awake in a class when group work was used. The positive comments made by students in their diaries indicated that co-operative learning was conducive to teaching. Evidence of their achievements needs to be investigated in terms of the scores of both the experimental and control groups.

4.5 SUMMARY

In order to answer sub-question one *(viz., What teaching strategies are implemented in the N3 class?)* non-scheduled structured interviews were conducted to determine teaching strategies employed by other lecturers teaching Engineering Science N3. Data required to answer sub-question two *(viz., How can co-operative learning strategies be successfully implemented?)* of this study were obtained by conducting an extensive literature review in

chapter two. The data for both these sub-questions were analysed and reported on in this chapter.

Data for sub-question three *(viz., How do the results of students exposed to co-operative learning strategies compare with students who are not exposed to co-operative learning strategies?)* is of a quantitative nature and required further statistical analysis. This analysis included descriptive, *t*-test and regression analysis and investigated any deficiencies in the test results of the control and experimental groups. The interpretation of this data and the findings are presented in chapter five.

CHAPTER FIVE

RESULTS, STATISTICAL ANALYSIS AND INTERPRETATIONS

"Interpretation of the statistical results depends heavily on producing data of a high quality" (Schumacher & McMillan, 1993, p.191)

5.1 INTRODUCTION

The results of sub-question three directly addresses the principle question, this examines the influence that co-operative learning had on the test results of N3 Engineering Science students. To answer this question it is necessary to analyse and interpret the student test scores. In line with this, the scores of students who were taught in a co-operative learning environment are compared with students who were taught by using the traditional teaching method.

For numerical data to be valid, further statistical observations in the form of descriptive, *t*-test and regression analysis are needed. The aim of this is to standardise any deficiencies that might have occurred in the pre-test results of both the control and experimental groups. In addition, efforts are made to determine whether student attendance had any affect on their test results.

5.2 STATISTICS

Statistics, according to Schumacher and McMillan (1993, p.191) are "methods of organising and analysing quantitative data". They explain that the interpretation of the

statistical results depends heavily on producing data of a high quality. Two methods can be employed to assist statistical analysis of data namely, *descriptive and inferential techniques* (Schumacher & McMillan, 1993; Behr, 1983; Leedy, 1997). Leedy (1997, p.36) stresses that "although statistics is not the only way data may be significantly comprehended, it is a most insightful tool, and it's importance should not be undervalued". Chapter four involved qualitative analysis of the descriptions provided by both lecturers and students.

5.2.1 INFERENTIAL STATISTIC ANALYSIS

Inferential statistical analysis studies the characteristics displayed by a sample of subjects. Using the conclusions, it then makes inferences or predictions about the entire population from which the sample is drawn (Schumacher & McMillan, 1993).

5.2.2 DESCRIPTIVE STATISTIC ANALYSIS

Descriptive statistical analysis transforms a set of numbers or observations into indices that describe or characterise the data. It uses mathematical formulae to reduce large quantities of observations into a few numbers, which represent the observations in each group of interest (Schumacher & McMillan, 1993). As descriptive statistics form the backbone of this study, its alternative, namely inferential statistics, will not be further discussed.

To answer sub-question three, (viz., *How do the results of students exposed to co-operative learning strategies compare with students who are not exposed to co-operative learning strategies?),* an experimental and control group consisting of thirty students each were used. The control group consisted of 21 black male students, three white male students, two coloured male students, one Indian male student, one Chinese male student

and two black female students. The experimental group consisted of 22 black male students, two white male students, two coloured male students and four black female students. The average pre-test result of the control group was 41.57 percent and that of the experimental group was 40.67 percent. The method of creating the two groups as discussed in chapter four ensured that they were matched in terms of their performance. The reason for the control group having a higher average is that in each matched pair the student with the higher mark was placed in the control group. The average age of the students in the control group was calculated to be 21.87 years and that of experimental group was 21.60 years again showing very little, if any, difference in the average age of students.

From the above it can be detected that the experiment and control groups were equivalent in all the criteria that could influence the results of this study, the only difference being the way in which the two groups were taught. All other variables that could have an influence on the dependent variable (e.g. times of class, possible distractions, careful screening of learning material to ensure same new content for both groups etc.) were kept constant for both groups. Schumacher and McMillan (1993) implied that standardising all factors for both groups is about controlling variables that could affect the dependent variable.

On completion of the experiment whereby the traditional teaching approach was used on the one hand and co-operative learning on the other, both the experimental and the control groups were subjected to the same post performance test. The post-test question paper was set up by a neutral colleague who had no interest in either the experimental or the control group. The duration of the test was ninety minutes and the time was strictly adhered to. The test scripts were moderated by another neutral colleague who also had no interest in either of the two groups. The moderator was also unaware of the origin of each of the test scripts. (i.e. Test scripts from the experimental group were integrated with test

scripts from the control group prior to the marking thereof). The results obtained by both groups in the post-test were recorded.

5.2.3 ANALYSIS OF THE COMPARATIVE TEST RESULTS

A comparative analysis of the data resulting from the marks obtained by students in both the pre-test and post-test was conducted. Schumacher and McMillan (1993), asserted that it could be possible in a pre-test/post-test scenario for the pre-test to positively influence the results of students in the post-test. However, to overcome this, students were tested on two different sections of the syllabus. Linear Motion was the assessment topic for the pre-test while Moments were assessed in the post-test. This eliminated any chance that the pre-test could have provided practice on the type of questions asked in the post-test.

When measurement (pre-test) precedes the treatment, some degree of error occurs which can only be corrected by making use of statistical regression. Schumacher & McMillan, (1993), explain that statistical regression refers to the tendency of subjects to score very high or very low in their post-test regardless of their results in their pre-test.

Table 5.1 provides some descriptive statistics for the three variables, *pre-test, post-test* and *Attend* (frequency of attending classes by student). The statistics are provided for each of the two groups, as well as for the whole group of 60 students.

TABLE 5.1: BREAKDOWN OF DESCRIPTIVE STATISTICS

Breakdown Table of Descriptive Statistics
N=60

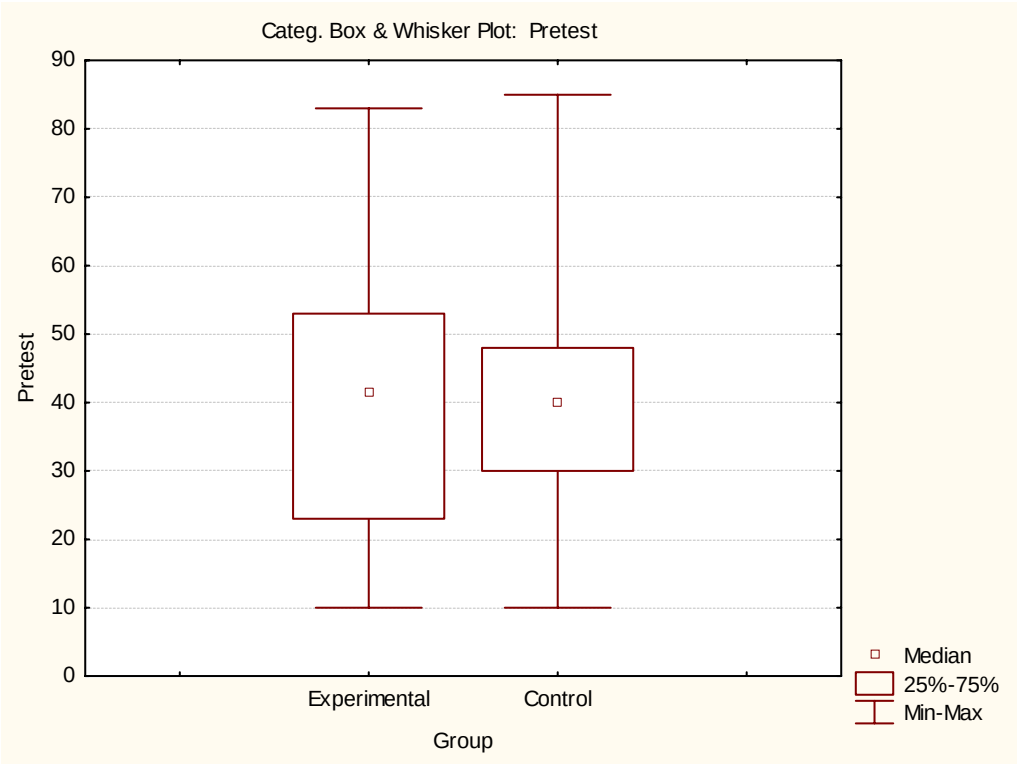
Group	Pretest Means	Pretest N	Pretest Std.Dev.	Posttest Means	Posttest N	Posttest Std.Dev.	Attend Means	Attend N	Attend Std.Dev.
Experimental	40.667	30	19.770	48.867	30	21.404	4.433	30	0.817
Control	41.567	30	19.755	33.733	30	17.856	4.300	30	0.952
All Grps	41.117	60	19.599	41.300	60	20.979	4.367	60	0.882

In the table above it can be seen that the groups differ only slightly on their pre-test mark, while there is a significant difference on their post-test mark. On their average attendance, a very small difference can be noted. These pre-test results are in line with Behr's observation that within the equivalent-group experiment the groups must be matched in all respects. The post-test results show that the experimental group did significantly better than the control group. However, Behr (1983) warns against using these results to make generalisations as the one group may become more enthusiastic or motivated as a result of their pre-test scores. Since the two groups were well matched there was no possibility that this had occurred.

5.3 MARK DISTRIBUTION FOR PRE- AND POST TESTS

Figure 5.1 and 5.2 below are Box-and-Whisker plots, showing the distribution of marks on the pre- and post-tests, separately for the two groups. The first diagram shows the *pre-test scores* of both the experimental and control groups while the second diagram shows the *post-test scores* of both these groups. According to Pinkey (2003, p.1) box and whisker diagrams can be used to show the spread of the data. "The diagram is made up of a 'box', which lies between the upper and lower quartiles. Dividing the box into two indicates the median. The 'whiskers' are straight lines extending from the ends of the box to the maximum and minimum values. Such points are known as outliers".

FIGURE 5.1 **MARK DISTRIBUTION FOR THE PRE-TEST SCORES**



From the diagram it can be seen that the lowest mark in the pre-test for both groups are the same at 10% while the highest marks are above 80%. The median for both groups are in the region of 40% while the majority of marks recorded from the experimental group are clustered around 25% to 55% and that of the control group between 30% and 48%. This reiterates that both these groups were equal in terms of ability at the start of the experiment.

FIGURE 5.2 **MARK DISTRIBUTION FOR THE POST-TEST SCORES**

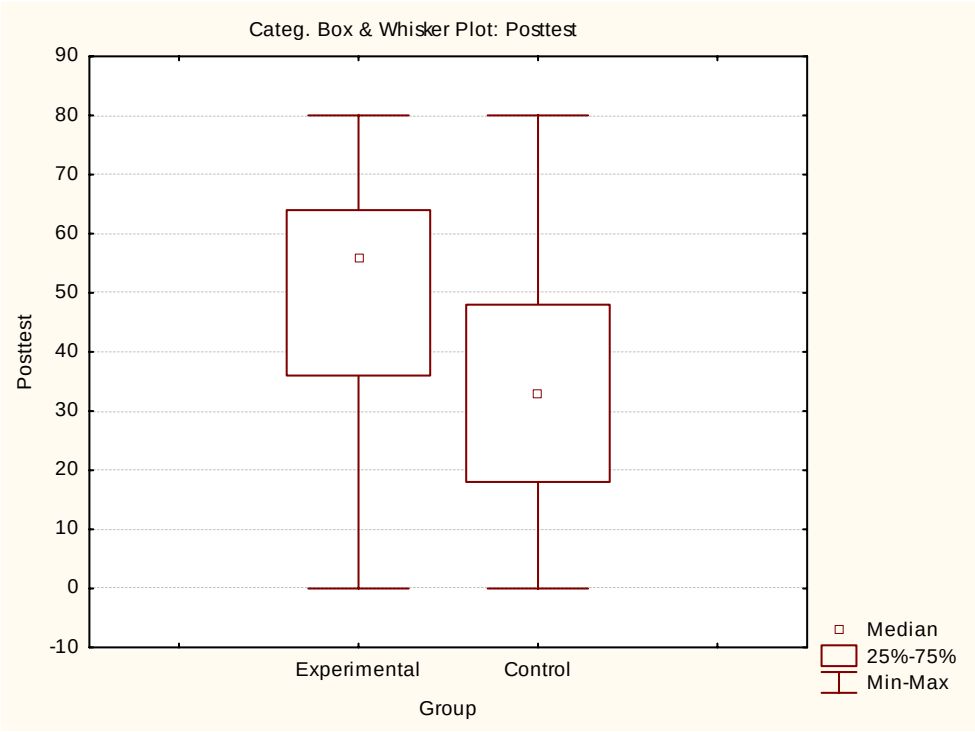


Figure 5.2 shows the post-test scores of both the experimental and control groups. Again both the experimental and control groups achieved the same minimum and maximum test scores namely, 0% and 80% respectively. However, the median of the experimental group was between 55% and 60% while that of the control group was between 30% and 35%. Furthermore, the diagram indicates that the majority of the students in the experimental group scored between 35% and 65% whereas those in the control group scored between 18% and 48%. It is therefore evident that the experimental group out-performed the control group by a substantial margin in the post-test.

5.4 CRITERIA EMPLOYED FOR STATISTICAL CORRELATION COEFFICIENT (*P*-VALUES)

According to Leedy (1997) the strength of relationships and interrelationships of data within the statistical process are known as correlation. It is always represented by a decimal fraction and indicates the degree to which the data is related, hence the name *correlation coefficient (r).* Behr (1983) explains that when the strength of a relationship *(r)* has a value of 0.2 the relationship is seen as almost negligible. When this value is increased between 0.9 and 1.00 the strength of the relationship is deemed to be very high, rising to perfection. However, Schumacher and McMillan (1993) warn that one should guard against confusing correlation coefficients with percentages as both are expressed in terms of decimals. They emphasise that many researchers prefer the term 'significant' for the correlation of relationship at a specified level of confidence. Furthermore, researchers generally agree that statistical differences are seen as significant when the *p*-value is equal to or less than 0.05. A *p*-value greater than 0.05 is labelled to be statistically non-significant. The researcher used a *p*-value of 0.05 as criterion to determine whether the statistical difference between the pre-test and post-test scores was of any significance. In addition the effect that student attendance had on the test results was also correlated.

5.5 ANALYSIS OF VARIANCE *(ANOVA)*

Schumacher and McMillan (1993) claim that a one-way analysis of variance *(ANOVA)* is simply an extension of the t-test. "Rather than using multiple *t*-tests to compare all possible pairs of means in a study of two groups, *ANOVA* allows researchers to test the differences between all groups and make more accurate probability statements" (Schumacher & McMillan, 1993, p.349). Table 5.2 gives the results of an *ANOVA* that was performed in

order to check for a significant difference between the two groups on the three variables which are pre-test, post-test and their attendance.

TABLE 5.2: ANALYSIS OF VARIANCE

Variable	Analysis of Variance Marked effects are significant at p < .05000							
	SS Effect	df Effect	MS Effect	SS Error	df Error	MS Error	F	p
Pretest	12.150	1	12.150	22652.03	58	390.552	0.031	0.861
Posttest	3435.267	1	3435.267	22531.33	58	388.471	8.843	0.004
Attend	0.267	1	0.267	45.67	58	0.787	0.339	0.563

Table 5.2 reveals that the two groups differ significantly only in terms of their post-test marks (p=0.004). The pre-test and attendance variables show p-values of 0.86 and 0.56 respectively. It can therefore be concluded that the difference in the marks was insignificant when the control was compared to the experimental group for the pre-test. Furthermore, student attendance did not influence their test results.

5.6 CORRELATIONAL STATISTICS

Correlational studies examine the degree to which the differences in one variable can be related to the differences in another. These differences can either be represented in a table format or the relationship between two variables can be plotted as co-ordinates on a graph in the form of a scatter diagram (Schumacher & McMillan, 1993). In this study both tables and graphs were employed to represent correlations between the dependent and independent variables. This allowed the researcher to make efficient and effective conclusions with regard to the relationship between the variables or lack thereof.

Tables 5.3 and 5.4 below give the correlation coefficients between the three variables for each group.

TABLE 5.3: **CORRELATION CO-EFFICIENT FOR VARIABLES OF THE EXPERIMENTAL GROUP**

Variable	Correlations: Experimental group Marked correlations are significant at p < .05000 N=30		
	Pretest	Posttest	Attend
Pretest	1.00	0.39	-0.11
Posttest	0.39	1.00	0.44
Attend	-0.11	0.44	1.00

TABLE 5.4: **CORRELATION CO-EFFICIENT FOR VARIABLES OF THE CONTROL GROUP**

Variable	Correlations: Control group Marked correlations are significant at p < .05000 N=30		
	Pretest	Posttest	Attend
Pretest	1.00	-0.04	0.22
Posttest	-0.04	1.00	0.28
Attend	0.22	0.28	1.00

From the above tables it can be seen that there are no significant correlations in the control group, while in the experimental group the correlation between the pre-test and post-test is significant, as well as the correlation between the post-test and attendance. The scatter graphs are shown in figure 5.3 and 5.4.

5.7 ANALYSIS OF COVARIANCE *(ANCOVA)*

This technique is used in situations where two or more groups are to be compared on their mean outcome on a response (dependent) variable, while controlling for the effect of one or more independent variable (covariates) (Mendenhall & Sincich, 1996; Schumacher &

McMillan, 1993). *ANCOVA* is commonly used in situations where two groups, a control and experimental group, are compared on their outcome on a post-test, controlling for the effect of a pre-test. When comparing two groups, *ANCOVA* takes into consideration how the group means differ on the pre-test, in other words it looks at post-test mean differences as if the two groups' means were equal on the pre-test (Mendenhall & Sincich, 1996; Schumacher & McMillan, 1993).

In this research the hypothesis that needs to be tested is whether there is a difference between the control and experimental group's outcome on the post-*test (dependent variable).* There are two covariates *(independent variables)* that need to be controlled for, namely the pre-test and the frequency of attending classes by the students. Schumacher and McMillan (1993) support this argument by stating that "covariates are often pre-test scores". The other variable that is considered and controlled is that of student attendance while participating in the experiment.

One of the critical assumptions in an *ANCOVA* is that the effect of the covariates is the same for the groups. Violation of this assumption has serious implications when the results are interpreted, and will lead to incorrect conclusions (Mendenhall & Sincich, 1996). This assumption was not violated. The data was examined for the presence of group-specific effects. This was done by visually comparing the slopes of the regression lines for the different groups in a scatter plot where the dependent
variable is plotted against each covariate. A statistical test can also be performed to see whether there are significantly different effects by entering an interaction term (covariate by group) in the model. If this term is statistically significant, it means that the effect of the covariate is different for the groups (Mendenhall & Sincich, 1996).

This is in line with Schumacher & McMillan's (1993, p.213) suggestion that "graph representation of the relationship between variables can be achieved by forming a visual array of the intersection of each subject's scores on the two variables".

FIGURE 5.3 **PRE-TEST SCORES VS. POST-TEST SCORES FOR EXPERIMENTAL AND CONTROL GROUPS**

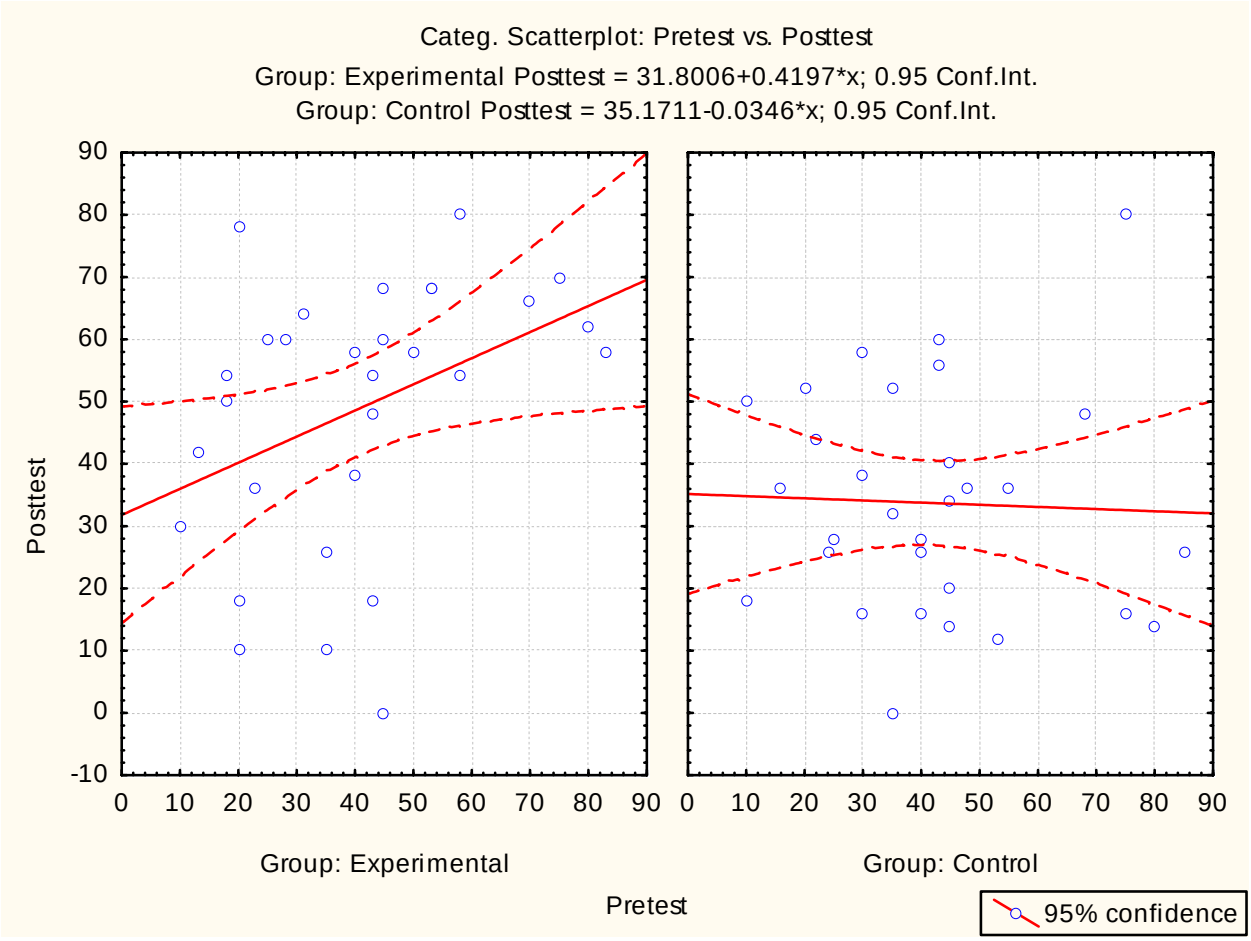
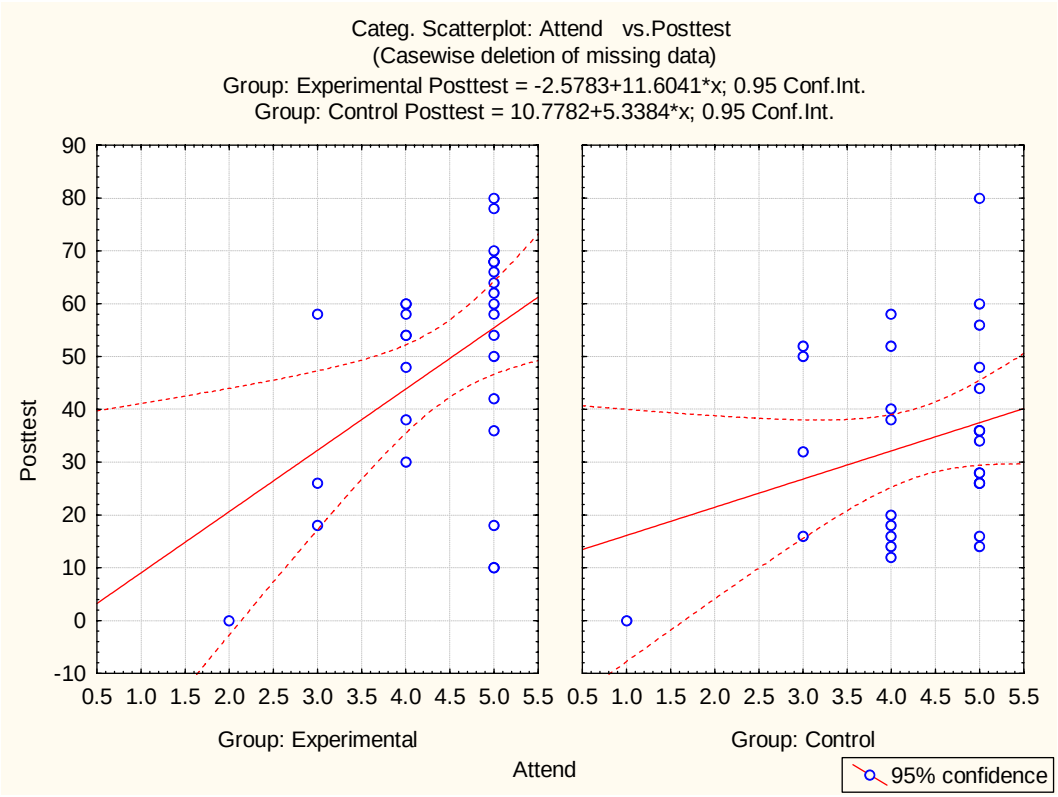


FIGURE 5.4 **POST-TEST SCORES VS. ATTENDANCE FOR EXPERIMENTAL AND CONTROL GROUPS**



The above graphs show that the effect of the pre-test is different for the two groups (the slopes are very different), but not the effect of attendance (the slopes differ only slightly). This means that we have to include the 'pre-test by group' interaction in the *ANCOVA* model. The following table gives the results of this analysis.

TABLE 5.5 **A REGRESSION SUMMARY OF B AND *P*-VALUES USING THE POST-TEST AS DEPENDANT VARIABLE**

	Regression Summary for Dependent Variable: Posttest R= .58511738 R^2= .34236234 Adjusted R^2= .29453415 F(4,55)=7.1582 p<.00010 Std.Error of estimate: 17.621					
N=60	Beta	Std.Err. of Beta	B	Std.Err. of B	t(55)	p-level
Intercept			1.088	12.745	0.085	0.932
Group	-0.241	0.260	-10.010	10.834	-0.924	0.360
Pretest	-0.120	0.157	-0.128	0.168	-0.763	0.449
Attend	0.371	0.111	8.831	2.651	3.331	0.002
Gr_Pre	0.692	0.280	0.586	0.237	2.470	0.017

Table 5.5 shows that a fair amount of the variability in the post-test is explained by the four predictor terms, namely 34.2%. This value drops to 29.5% if it is adjusted for the relatively small sample and the number of predictors in the model. Apparent from the table is the significant 'pre-test by group' interaction effect (indicated by *Gr_Pre)* and also that attendance has a significant positive effect on the post-test.

In order to investigate the post-test group differences, they need to be evaluated at different levels of the pre-test because of the presence of the interaction effect. The following table shows how the two groups differ on the post-test at a few selected levels of the pre-test.

TABLE 5.6 **DIFFERENTIATED SCORES OF THE TWO GROUPS ON THE POST-TEST AT SELECTED PRE-TEST LEVELS**

Selected Pre-test value	Average attendance	Post-test estimate in Control group	Post-test estimate in Exp. group	Difference (Exp.-Cont.)
10	4,37	38,4	34,3	-4,1
30	4,37	35,8	43,4	7,6
50	4,37	33,1	52,6	19,5
70	4,37	30,7	61,8	31,1
90	4,37	28,1	70,9	42,8

The five selected pre-test marks in the first column range from 10 to 90 across the scale of the pre-test. In all cases the same attendance value (second column), namely the sample mean of 4,37 is used, since the effect is the same for all values. The third column gives the estimated post-test mark for a student in the control group with a pre-test mark equal to the value in the first column, while the fourth column gives the equivalent for a student in the experimental group. The last column gives the difference between the two post-test estimates (Post-Experimental – Post-Control).

Inspection of the last column shows that at the lower end of the pre-test scale, the experimental group did not do much better in the post-test than the control group. At very low marks they are even estimated to do worse. However, the further one goes up the scale, the bigger the difference gets in favour of the experimental group. In the middle of the scale (at a pre-test mark of 50), the experimental group is estimated to perform better than the control group by almost 20 marks, while this value increases to about 40 at the very top of the scale.

5.8 SUMMARY

In this chapter, the data to answer sub-question three (viz., *How do the results of students exposed to co-operative learning strategies compare with students who are not exposed to co-operative learning strategies?)*, the principle question on which this research study hinges, was statistically analysed, interpreted and discussed. The statistical analysis of the differences in the science test results of the experimental and control group included descriptive analysis, ANOVA, ANCOVA and regression analysis. In addition, correlations on the relationships between the pre-test, post-test and student attendance for both the experimental and control groups were determined and reported on.

In chapter six conclusions relating to the analyses will be made. As a result of these conclusions the hypothesis will be verified and recommendations will be made. Recommendations on the necessity for further research on this topic will also be discuss.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 INTRODUCTION

The poor examination pass rate of some of the subjects presented at the PEC has been a point of concern for a considerable period of time. The percentage pass rate of a subject refers to the number of students who passed that particular subject against the number who wrote the examinations. At the PEC, the examination pass rate for every subject is compared to that of the national pass rate. When the College's pass-rate for a specific subject is less than that of the National pass rate, the results are deemed poor. One subject which is below par is that of Engineering Science N3. Being a Science lecturer, I was personally concerned and this prompted me to investigate ways of improving the results.

This chapter examines the analysis of the data obtained when a co-operative teaching technique was used. It then draws conclusions from the analysis. The conclusions lead to three recommendations being made.

6.1 THE HYPOTHESIS

Thy hypothesis stated in chapter one was:

Co-operative learning strategies will improve the test results of science learners in the N3 class.

In chapter five the results of the analysis obtained using ANOVA and ANCOVA indicate that there is a significant improvement in the test results of the students in the experimental group. The teaching technique decided on for the experimental group was the co-operative learning strategy. Within this strategy the STAD approach was used. The main conclusion is that co-operative learning strategies improved the test results of the experimental group. This therefore proves the hypothesis.

6.3 FURTHER CONCLUSIONS

Data to answer sub-question one (viz., *What teaching strategies are generally implemented in the N3 class?)* was obtained by conducting interviews with lecturers who have taught Engineering Science for at least three years. Chapter four indicates that only one (lecturer A) out of four lecturers has tried to change his teaching strategy. Another one (lecturer B) is open to change but has no clear direction as to how to change. The other two (lecturer C and lecturer X) are not keen to change. Since the results of students in lecturer X's class did not change significantly it can be concluded that lecturer X's teaching technique is not conducive to improving students' marks.

In answering sub-question two (viz., *How can co-operative learning strategies be successfully implemented*?) the strategy chosen for the experimental group was the STAD approach. It can be concluded that by using this approach the results of most of the students in the experimental group improved significantly (See chapter five). This is also evident in the actual marks of the 30 students in the experiment group.

Additional information was obtained from group diaries wherein students (from the experimental group) recorded their views of co-operative group work. The comments of

the students indicated that they enjoyed learning when the co-operative approach was used.

6.4 RECOMMENDATIONS

There are three recommendations that could help to improve the examination results of N3 Engineering Science students. Lecturers at FET Colleges should be encouraged to make the paradigm shift away from traditional teaching.

6.4.1 FIRST RECOMMENDATION

Provide staff development for lecturers to change. The training must encourage and assist lecturers to make the paradigm shift away from traditional teaching to a learner centred approach. Freire (1972) warns against traditional teaching and refers to it as the 'banking concept' in which students are reduced to empty vessels waiting to be filled with knowledge. This is contrary to what is expected in OBE.

6.4.2 SECOND RECOMMENDATION

Re-structure the curriculum to include new methods of teaching and assessment. SA is currently celebrating its tenth year of democracy and the strength of its education system lies in the diversity of its people. It is therefore non-negotiable that our youth are provided with the best possible opportunity to develop to their fullest potential. In the new dispensation, where FET Colleges have been separated from their FET counterparts in the schools, it is extremely important that the curriculum for FET Colleges is restructured to incorporate OBE. Incorporating OBE would result in the scrapping of the traditional method of teaching.

Restructuring of the curriculum would bring FET Colleges in line with the country's vision of OBE, which embraces co-operative group work as one of its cornerstones.

6.4.3 THIRD RECOMMENDATION

Change to a semester system. All four lecturers interviewed see the trimester system associated with FET Colleges as a restriction to their creativity within the classroom. Pressure arising from the limited time for finishing the syllabus prevents them from exploring alternative teaching approaches. It is therefore paramount that the current trimester system is abolished and replaced with semesters.

6.5 FURTHER RESEARCH

A number of limitations could have restricted the outcome of this study. Some, the researcher had no control over. These limitations could be overcome when further research in this area is conducted.

The time available in a trimester cycle limited this study to a period of four weeks. With the result that only one section of the syllabus could be subjected to the co-operative learning strategy. Although enough data was collected to successfully complete this study, I feel that if this study could have covered a wider cross-section of the learning content more accurate statistical analysis could have been made. Data obtained from group diaries from the experimental group verified this as students clearly indicated that they enjoyed working co-operatively and wanted all their lectures in this new form. Further research could be conducted over a full trimester.

A second limiting factor was the small sample of students who participated in this study. The sample was restricted to students who studied at the RRC of PEC. This conveniently created sample immediately restricted any generalisations that could be made regarding the larger population of N3 Engineering Science students studying at other FET Colleges in SA. Further research at these Colleges would be required to substantiate whether the results of this study could be employed to make generalisations about the broader population.

Lastly, the overwhelming majority of black male students present in the sample could be seen as a possible limitation to this study. The positive social interaction between the students was encouraging, however, it remains to be seen whether this would have been the case if a more diverse experimental group was created. It is therefore fundamentally important to create a more diverse sample in which inter-racial, cultural and ethnic relationships are further researched. This study should also be conducted over a longer period in order to determine whether these newly developed friendships would last.

6.6 SUMMARY

This study, as well as studies undertaken by Potgieter (2003) and Mkhabela (1994), seems to suggest that students' academic achievements and social skills are enhanced when they work collaboratively with their peers in groups. Therefore, it is in the best interest of our students that the paradigm shift towards a co-operative learner-centred environment be made.

After examining the results of the analysis of the data in chapters four and five this chapter drew conclusions thereby proving the hypothesis stated in chapter one. Furthermore,

recommendations that will help to improve the examination results of N3 Engineering Science students are made.

The overarching conclusion to be inferred is that if lecturers change their teaching style to include co-operative learning, this could improve the students' results.

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