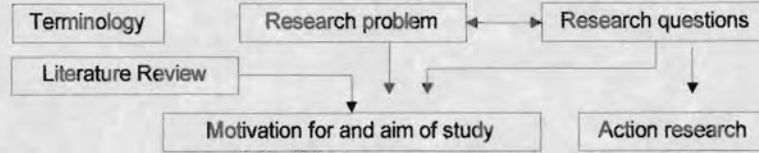
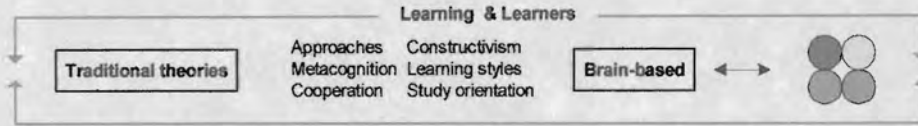




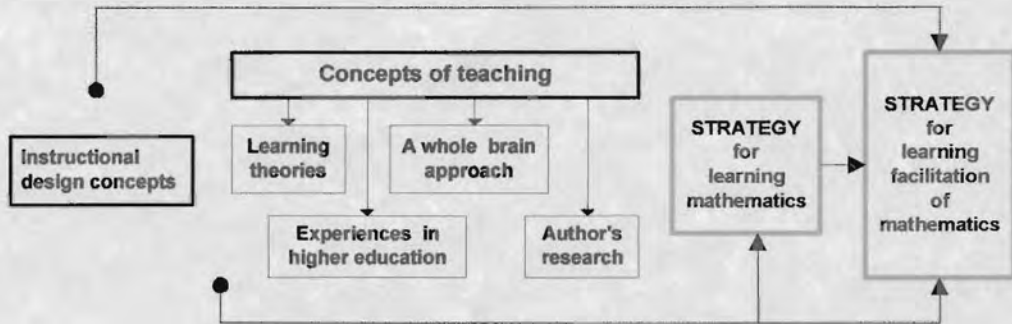
**Chapter 1**



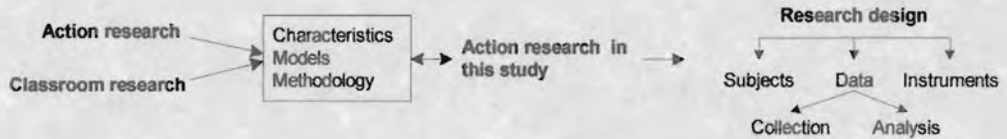
**Chapter 2**



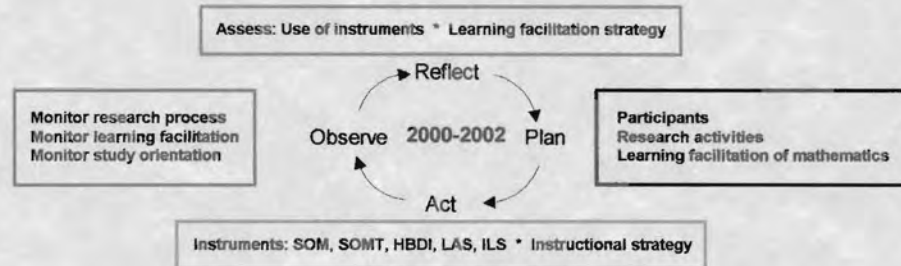
**Chapter 3**



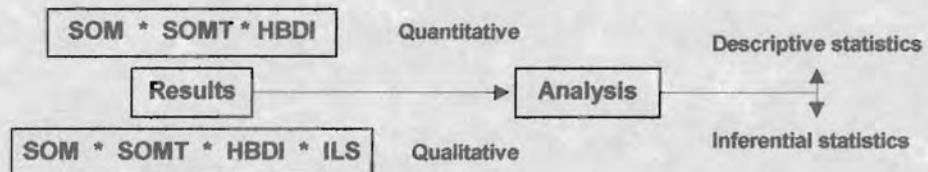
**Chapter 4**



**Chapter 5**



**Chapter 6**



**Chapter 7**





# Orientation

## 1.1 Motivation for the study

## 1.2 Explanation of the title and definition of the terminology

1.2.1 Learning

1.2.2 Facilitation

1.2.3 Learning facilitation

1.2.4 Strategy

1.2.5 Mathematics

1.2.6 Support course

1.2.7 First year engineering students

1.2.8 Additional terminology

## 1.3 The main research problem

## 1.4 The main research questions

## 1.5 Research hypotheses

## 1.6 Recent research in tertiary mathematics education

## 1.7 Research design overview

1.7.1 Aim of the research

1.7.2 Research approach

1.7.3 Participants in the study

1.7.4 Data collection and analysis

1.7.5 Validity and reliability

## 1.8 Research ethics

## 1.9 Overview and structure of the thesis

# Chapter 1

## Orientation

### 1. Introduction

The state of mathematics learning and teaching in South Africa cannot be regarded as adequate if the results obtained from the Third International Mathematics and Science Study (TIMSS) in 1995 are considered. In this study South African learners were rated last amongst the 42 countries that participated in the study (Gray, 1997:v). In 1998 a further study, the TIMSS-Repeat (TIMSS-R) was done. South African pupils again performed poorly when compared to other countries. The score of 284 points out of a possible 800 for South Africa is well below the international average of 487 for the 38 countries that participated in the TIMSS-R (Howie, 2001:2). Results like these not only portray a bleak picture of the mathematical competence level of South African students entering tertiary study but also compel educators of mathematics to rethink the learning facilitation of mathematics at all levels including tertiary education.

Statistics made available by the Bureau for Institutional Research and Planning (2001) at the University of Pretoria (UP) on the pass rate for mathematics in the South African matriculation exams during 1997-1999 indicate that less than 40% of students who write mathematics on higher grade pass. In 2000 fewer students wrote mathematics on higher grade and 50.2% passed. The trend for 1997-2000 seems to be that about 19 000 students per year passed mathematics on higher grade.

Furthermore, statistics reflecting on the pass rates of engineering students at the UP in the early 1990s indicate that only one out of every four freshman enrolments completed the degree programme in the scheduled four years and one out of every three students left the university without obtaining any qualification.

These figures are not encouraging for a developing country like South Africa in the early 2000s where increased scientific and technological expertise is needed. The success of prospective students, who have the potential to enter tertiary study to pursue careers in the

natural sciences, may be seriously at risk if they come from an educational background deficient in high-quality mathematics instruction. These students can benefit from support, other than remedial measures, in the learning facilitation of mathematics. The focus in this study is thus on the learning facilitation of mathematics of first year engineering students at the UP who have passed the admission test assessing their ability to succeed at engineering studies but who are academically still at risk because of deficiencies in their educational background.

The regular university engineering programme in South Africa requires four years of full time study as regulated by the Engineering Council of South Africa (ECSA). In 1994 the School of Engineering at the UP instituted an extended study programme, the Five Year Study Programme (5YSP). This programme increases the duration of the regular engineering study from four years to five years and is structured in such a way that the academic courses of the first two years of the regular four year study programme are spread over the first three years of the 5YSP.

The purpose of the 5YSP is to create an opportunity for students who have the potential to become engineers but who do not meet the entrance requirements for the regular four year programme and/or are academically at risk of not completing their studies through the regular four year study programme. All the students on the 5YSP are given extensive academic support in their first year engineering courses through tutoring given by senior (engineering) students. Due to varying levels of educational competency in schools and a lack of exposure and access to technology that some students on the 5YSP experienced in their high school years, an additional two-semester credit-bearing course, the Professional Orientation Support Course (POSC), is offered during the first year of study. The course comprises of a conceptual mathematics component, the development of personal skills, communication skills and skills in information technology. The course content provides a broad academic background to mainly black students who are presently an underrepresented minority in engineering study in South Africa.

This thesis reports on the learning facilitation strategy for mathematics that was followed in the POSC during 2000, 2001 and 2002.



## 1.1 Motivation for the study

In November 1999 the author joined the 5YSP in the School of Engineering as lecturer responsible for the POSC. This posed the opportunity to implement the experiences and results gained during the author's involvement with students in the Faculty of Natural Sciences since 1991 and action research conducted during 1993-1999 in the Faculty of Natural Sciences with students on an extended study programme in the Faculty of Natural Sciences.

Experiences during the 1993-1999 studies indicated that the use of a computer graphing tool can enhance mathematical conceptualisation of two dimensional functions (Steyn, 1998). The 1998 and 1999 studies also added, among other things, the following possible dimensions to the facilitation of mathematics at introductory calculus level. Firstly the 1998 study showed that first year tertiary students on a support course can benefit from training in study skills and mind mapping as one such skill could successfully be used as a study tool in mathematics (Steyn & De Boer, 1998). Secondly the 1999 study showed that a group of tertiary learners in mathematics displays an array of thinking and learning style preferences and it was envisaged that instructional approaches in mathematics should take cognisance of these when planning learning facilitation (De Boer & Steyn, 1999).

Although some data pertaining to students' experience of mathematics at school and in the calculus course of the extended programme was qualitatively analysed during the 1996-1998 studies (Steyn & Maree, 2002), no quantitative analysis was done. Moreover the mentioned research did not address the students' study orientation in mathematics.

The research during 2000-2002 was undertaken to implement the experiences, gained with first year science students on a support course, in the learning facilitation of mathematics for first year engineering students on the POSC. In this way a strategy for the learning facilitation of mathematics for first year engineering students on a support course could be developed. In addition, a profile of these students' study orientation in mathematics and their thinking and learning preferences could be compiled.

## 1.2 Explanation of the title and definition of the terminology

An explanation of the title, namely, *A learning facilitation strategy for mathematics in a support course for first year engineering students at the University of Pretoria*, will explain the meaning of the terminology involved as it is applied within the context of this study. Other terms used in this study will be defined as they occur.

### 1.2.1 Learning

*No one definition of learning is universally accepted by educational theorists, researchers, and practitioners. Definitions of learning are numerous and varied...*(Schunk, 1996:2).

As a universally accepted definition for human learning does not exist, the following views on learning give an indication of the essential aspects that describe learning as it is viewed in this study.

The concept "learning" is defined by Thompson (1995:774) as *to gain knowledge of or skill in by study, experience, or being taught and also to acquire or develop a particular ability*. Woolf (1977:654) defines "learning" as *knowledge or skill acquired by instruction or study*. Knowles (1990:147) points out that *to learn is to change*.

Gagné (1977:4) views learning as follows:

*Learning is a change in human disposition or capability, which persists over a period of time, and which is not simply ascribable to processes of growth. .... The change must have more than momentary permanence; it must be capable of being retained over some period of time ... it must be distinguishable from the kind of change that is attributive to growth.*

Kolb (in Zuber-Skerritt, 1992a:105) defines learning as

*The process whereby knowledge is created through the transformation of experience.*

Shuell (in Schunk, 1996:2) defines learning as

*Learning is an enduring change in behavior, or in the capacity to behave in a given fashion, which results from practice or other forms of experience.*

Herrmann (1998) summarises his views on learning as follows:

- Learning is a mental process.
- Learning occurs when intended information can be recalled from memory for independent applications.
- Learning involves the establishment of neural circuits, which provide pathways for mental processing. These neural circuits developed through learning are interconnected to the specialised long-term memory sites storing the learned information.

In 1999 the Committee on the Developments in the Science of Learning of the National Research Council in the United States of America (USA) published a contemporary account of principles of learning (Bransford, Brown & Cocking, 1999). Instead of restricting learning to a single definition of a *basic, adaptive function of humans* (Bransford *et al.*, 1999:xi), it is noted that

*A scientific understanding of learning includes understanding about learning processes, learning environments, teaching, sociocultural processes, and many other factors that contribute to learning.*  
(Bransford *et al.*, 1999:221).

The latter description of learning gives an indication of the extent of the context of human learning and this view is endorsed by the author of this thesis. In Chapter 2 an epistemological overview of learning and learners relevant to the focus of this study is given and in Chapter 3 the facilitation of learning is discussed.

## 1.2.2 Facilitation

Crowther (1995:414) and Woolf (1977:410) define the term "facilitate" as *to make an action or a process easier*. Gove (1961:812) gives the same definition and adds that the term also implies the acts of *assisting* or *aiding*. The relevance of the concept "facilitation" for education is endorsed by comparing the meaning of "facilitate" to that of "instruct". Gove (1961:1172) defines the term "instruct" as *to give skill or special knowledge or information*. Woolf (1977:599) defines "instruct" as *to direct authoritatively and on the basis of informed awareness* and Thompson (1995:706) also defines it as *to direct or to command*. These definitions highlight the difference between facilitation and instruction as approaches to teaching.

### 1.2.3 Learning facilitation

In this study the combined term "learning facilitation" is defined as *assistance in the process of knowledge creation and behavioural change that occur over a period of time.*

### 1.2.4 Strategy

Crowther (1995:1179) defines "strategy" as *a plan designed for a particular purpose* and Thompson (1995:1377) defines it as *a plan of action*. Woolf (1977:1150) defines it as a *careful plan or method*.

For the purpose of this study "strategy" is defined as a *careful plan of action designed for a particular purpose*.

### 1.2.5 Mathematics

Howsen (in Maree, 1997:14) distinguishes between the following perspectives in defining the term "mathematics":

*[Mathematics is] an abstract structure with seemingly miraculous inter-relationships, [or] a collection of interesting and potentially useful methods and results, [or] an activity that relies upon the participant's ability to conjecture, prove, generalize, model, apply, define.*

Steen (1988a) regards the science of patterns as an integral part of the concept "mathematics" and defines it as follows:

*Mathematics is often defined as the science of space and number, as the discipline rooted in geometry and arithmetic. Although the diversity of modern mathematics has always exceeded this definition, it was not until the recent resonance of computers and mathematics that a more apt definition became fully evident. Mathematics is the science of patterns ... it begins with the search for pattern in data ... Generalization leads to abstraction, to patterns in the mind. Theories emerge as patterns of patterns, and significance is measured by the degree to which patterns in one area link to patterns in other areas. Subtle patterns with the great explanatory power become the deepest results, forming the foundation for entire subdisciplines. (Steen 1988a:616).*

The term "pattern" is defined by Thompson (1995:1002) as *a regular or logical form, order or arrangement of parts*.





Gove (1961:1393) defines "mathematics" as a *science that deals with the relationship and symbolism of numbers and magnitudes and that includes quantitative operations and the solutions of quantitative problems.*

Lakoff (in English, 1997:3) defines "mathematics" as the *study of the structures that we use to understand and reason about our experience - structures that are inherent in our preconceptual bodily experience and that we make abstract via metaphor.*

Thompson (1995:840) defines the concept "mathematics" as the *abstract science of number, quantity and space studied in its own right.*

Dubinsky (1994:228) views mathematical knowledge and its acquisition as follows:

*A person's mathematical knowledge is her or his tendency to respond to certain kinds of perceived problem situations by constructing, reconstructing, and organizing mental processes and objects to use in dealing with the situations.*

According to Dubinsky (1994:228) the "tendency to respond" refers to the fact that a person may respond *in different ways at different times and in different places* and that the existence of a certain kind of knowledge does not imply that a person will exhibit that knowledge all the time. The "perceived problem situation" suggests that if a question is asked, *there is no guarantee that this perception of the question is the same as that of the person who posed it* (Dubinsky, 1994:228). The terms "constructing" and "reconstructing" indicate that a person's knowledge is not static.

Maree (1997:14) states that an etymological and semantical analysis of the word "mathematics" brings to light that the subject cannot be mastered without (almost every day) effort, learning, experience, practice, understanding, the will to learn, responsibility, self-discipline and perseverance.

For the purpose of this thesis mathematics is seen as a combination of the viewpoints above, namely, that **mathematics is a science of structures (patterns) and deals with relationships and symbolism, and that a person's interaction with mathematics is dynamic.**



### **1.2.6 Support course**

Crowther (1995:1200) defines the term "support" as *help or encouragement given to somebody especially in a difficult situation*. Thompson (1995:1400) gives different meanings of the term "support", all of which can be applicable to this study, namely, *keep from failing; encourage; give help; assist*.

### **1.2.7 First year engineering students**

The phrase "first year engineering student" refers to any freshman who is enrolled for the first academic year of engineering study.

### **1.2.8 Additional terminology**

The definitions of the following terms, used throughout this thesis, are briefly stated. The terms "higher education" and "tertiary education" are used interchangeably. In the South African context, these terms refer to formal education at universities, post-school academic institutions and technical colleges. The phrase "tertiary learner" refers to any learner at an institution for higher education.

## **1.3 The main research problem**

The research problem addressed in the current study focuses on the development of the mathematics potential of a learner with specific reference to the relationship between a learner's study orientation towards mathematics, a learner's academic performance in the first semester course in calculus and a learner's awareness of cognitive processing modes and thinking style preferences. This relationship presumably constitutes a profile of a learner's study orientation and thinking preferences towards mathematics. In the current study this relationship is viewed against the background of the learning facilitation strategy proposed and followed in the POSC.

## **1.4 The main research questions**

With regard to the students enrolled for the POSC, the aspects that constitute the relationship between study orientation in mathematics, performance in mathematics,



thinking style preferences and a whole brain learning facilitation strategy will be addressed in this thesis in an attempt to answer the following questions.

1. What is the study orientation towards mathematics of the students enrolled for the POSC?
2. Does the learning facilitation strategy followed in the POSC have an effect on the students' study orientation in mathematics? In particular, is there an improvement in the students' study orientation towards mathematics?
3. Does the learning facilitation strategy for mathematics followed in the POSC have an effect on students' academic performance in the standard first semester calculus course?
4. What are the thinking style preferences of first year engineering students enrolled for the POSC?

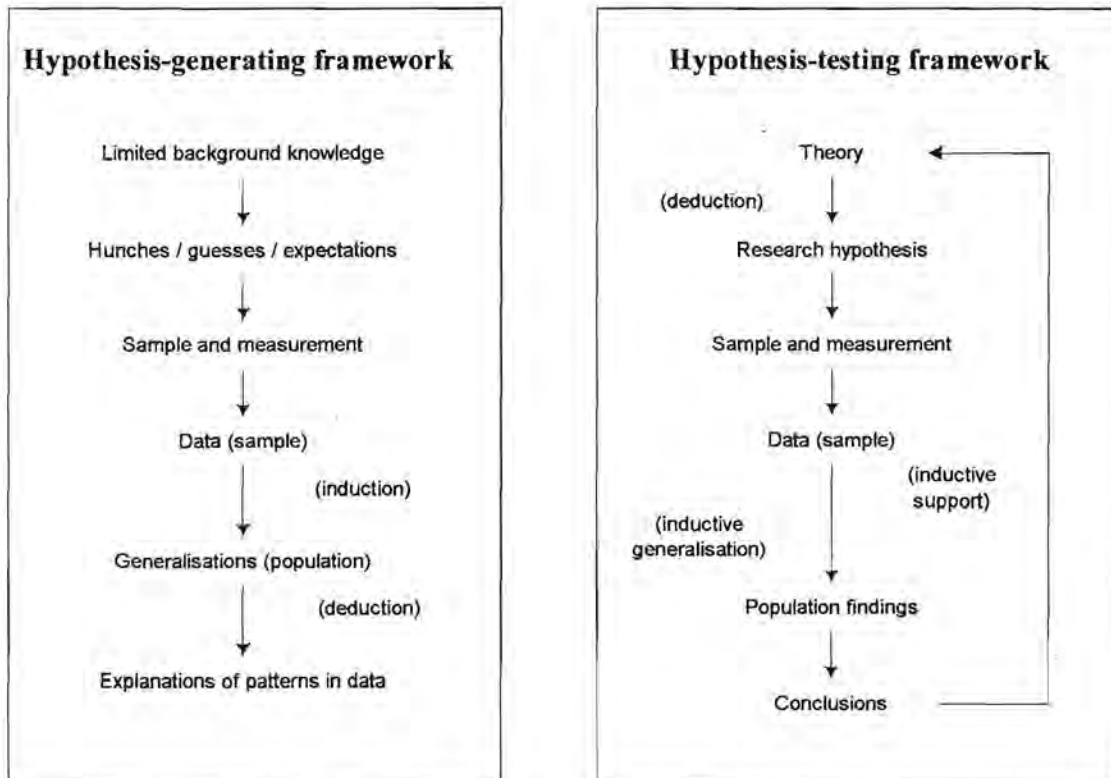
## 1.5 Research hypotheses

The research undertaken in the present study is twofold in nature. On the one hand the research is of an exploratory nature aimed at developing new hypotheses and on the other it is of a validation nature aimed at testing these hypotheses. The difference between a hypothesis-generating study and a hypothesis-testing study is illustrated in Figure 1-1. Mouton (1996) remarks that in a hypothesis-testing framework a research hypothesis is derived from an existing theory. A sample is identified and the hypothesis is tested. In a hypothesis-generating framework data is collected from a sample of cases and findings are generalized to the target population and patterns in the data are explained. Light, Singer and Willett (1990) also point out that data should be used not only to test theory but also to develop theory.

In the present study the research questions can be regarded as of a hypotheses-generating nature. These questions are aimed at determining the study orientation towards mathematics of the students enrolled for the POSC, their thinking style preferences and the effect that learning facilitation strategy for mathematics followed in the POSC have on

academic performance in the first semester course in calculus. Once generated, these hypotheses are investigated and evaluated with the participants<sup>1</sup> in the study.

**Figure 1-1 Hypothesis-generating and hypothesis-testing frameworks**

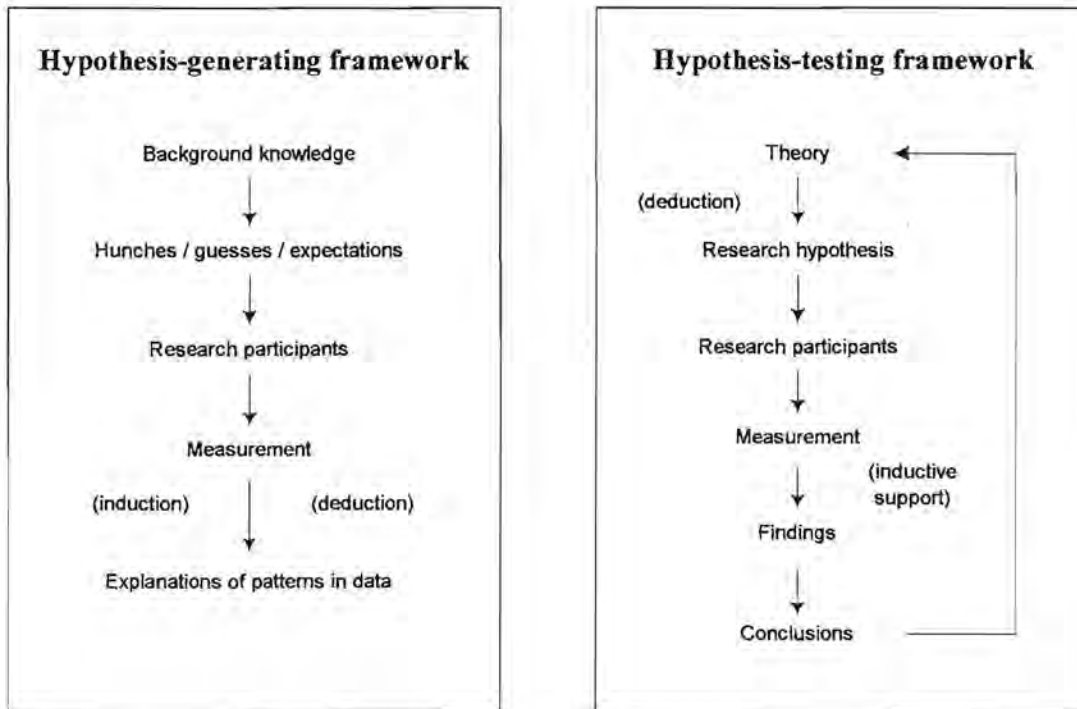


Adapted from Mouton (1996:82)

Mouton's framework as in Figure 1-1 above represents a view regarding social research in general. By the very nature of the action research approach followed in the present study where the focus is on particular participants in a specific situation, the aim with the research is not to generalise findings to a population. However, it may be possible to explain patterns in the data that could be of significance to a broader population. The framework in Figure 1-2 is a more probable representation of the hypothesis-generating and hypothesis-testing frameworks in the present study.

<sup>1</sup> The traditional notion of 'subjects' in a study is substituted with 'participants' as the latter term conveys one of the core aspects of an action research approach.

**Figure 1-2 Hypothesis-generating and hypothesis-testing frameworks in the present study**



Adaptation of Figure 1-1 for the present study by the author of this thesis

Concerning the **hypothesis-generating** aspect in the present study and according to the framework in Figure 1-2 the action research activities of the author during 1993-1999 form the 'background knowledge' from which 'hunches'/ 'guesses'/ 'expectations' are deduced. In the study reported in this thesis these 'hunches'/ 'guesses'/ 'expectations' are investigated with 'participants', relevant aspects are 'measured' and 'patterns in the data are explained'.

Concerning the **hypothesis-testing** aspect in the present study and according to the framework in Figure 1-2 the results of the action research activities during 2000 and 2001 generated hypotheses that could be regarded as 'theory'. Following from this 'theory', 'research hypotheses' could be formulated and again investigated with 'research participants'. The hypotheses could then be tested, the 'findings' reported and 'conclusions' drawn.



## 1.6 Research design overview

Mouton (1996:175) states that the objective of research design is to *plan, structure and execute the relevant project in such a way that the validity of the findings is maximized.*

For the research design of this thesis the following aspects are specified, namely the

- aim of the research
- research approach
- participants in the study
- data collection methods and instruments
- methods of data analysis
- ways in which the reliability, validity and objectivity of collecting the data have been controlled.

### 1.6.1 Aim of the research

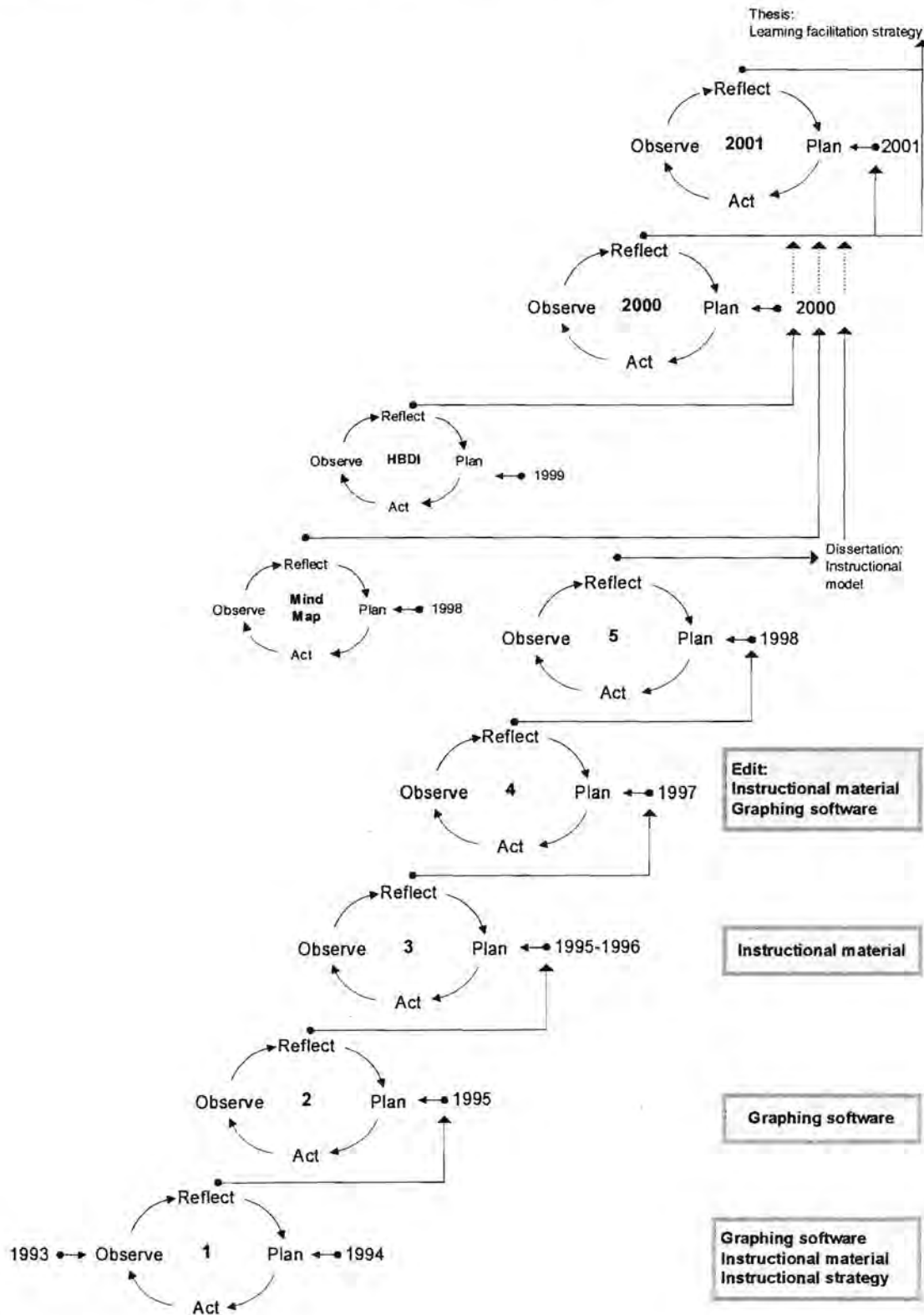
The primary objective of the research is to propose a strategy for the learning facilitation of mathematics in a support course for first year engineering students, to define the aspects that constitute such a strategy and to determine the possible effects of the strategy on learners' study orientation towards mathematics and on their performance in mathematics.

### 1.6.2 Research approach

The main research approach adopted for the study described in this thesis is action research. Cohen and Manion (1994:186, 192) define action research as a *small-scale intervention in the functioning of the real world and a close examination of the effects of such intervention.* The research approach in the present study also displays the core principles of *Classroom Research* as postulated by Angelo and Cross (1993) and Cross and Steadman (1996). In the opinion of the author of this thesis the principles underpinning an action research approach in education are similar to those proposed in the classroom research approach. In Chapter 4 the characteristics of these two approaches are given and the research model and methodologies of the present study are discussed. Figure 1-3 gives an outline of the action research activities of the present study as well as those that preceded and contributed to the current research.



Figure 1-3 Action research activities 1993-2001



Compiled by the author of this thesis



### 1.6.3 Participants in the study

In each of the two action research cycles during 2000 and 2001 that is reported in this study there are different groups of participants and categories of data that contribute to the findings of the study. The action research cycle during 2002 only involved one group of participants.

The main participatory groups consist of the first year students enrolled for the POSC during 2000-2002.

With regard to data pertaining to thinking style preferences, a group of first year civil engineering students also participated in the study during 2000. The results of a previous study (De Boer & Steyn, 1999) regarding the thinking style preferences of science students on a support course are also used to compare the thinking style preferences of first year engineering students and first year science students.

In addition to data regarding the mathematics performance of the POSC groups, the data of two other comparative<sup>2</sup> groups are also considered. The comparative groups comprise two groups of freshman engineering students. The one group consists of freshman students registered for the 5YSP but who are not enrolled for the POSC. The other comparative group includes freshman students registered for the regular four year study programme (4YSP). In Table 1-1 a summary of the data categories and participating groups are given.

**Table 1-1 Data categories and participants in the study**

Data	Contributing participants						
	POSC 2000	POSC 2001	POSC 2002	First Year Civ Eng	Science Students	4YSP	Other 5YSP
Thinking style preferences	✓			✓	✓		
Study orientation	✓	✓	✓				
Mathematics performance	✓	✓	✓			✓	✓

Compiled by the author of this thesis

<sup>2</sup> The traditional notion of 'control' group is substituted with 'comparative' group to indicate data that is compared to that of the participatory group.



#### 1.6.4 Data collection and analysis

The collection of data pertaining to the participatory group formed part of the formal activities of the POSC. The data concerning the mathematics grades was obtained from the official records of the university.

Qualitative and quantitative methods and instruments were used with the participatory groups so that the effects of the learning facilitation strategy of the support course could be observed and monitored. The qualitative means by which the data was collected included questionnaires, observations and interviews. The quantitative means included questionnaires and official student records.

#### 1.6.5 Validity of action research

Zuber-Skerrit (2001) argues that validity of research in the social sciences has a different meaning in different paradigms and is relative with regard to a researcher's philosophical assumptions and epistemological framework. She points out that within the social sciences, there are two main competing paradigms, namely the positivist and the phenomenological. The traditional positivist paradigm uses methods that are predominantly quantitative and in the alternative phenomenological paradigm (of which action research is an exponent) the methods are predominantly qualitative although both these methods are used in both approaches.

Furthermore, an investigator's philosophical assumptions and epistemological framework will not only determine the research approach but also the process and methods that are chosen. Zuber-Skerrit points out that the concept "validity" in the traditional (positivist) approach to research *is recognised as assured when knowledge is generalisable and when the study is conducted in controlled conditions, using rigorous methods of data collection, analysis and interpretation* (Zuber-Skerrit, 2001: in press).

On the other hand, Zuber-Skerrit argues that from the phenomenological paradigm (as in action research) the researcher's role is to describe and explain the situation or case as truthfully as possible. She continues to say that the aim is *not to establish generalisable laws for multiple contexts, but to know, understand, improve or change a particular social situation or context for the benefit of the people who are also the participants (not just*



*subjects) in the inquiry and who are affected by the results and solutions (Zuber-Skerrit, 2001: in press).*

For Zuber-Skerrit validity in the phenomenological paradigm is more *personal and interpersonal than methodological, and should be based on interactive dialectic logic* rather than on a dichotomy of subjective or objective truth. She concludes that the action researcher is *interested in perspectives, rather than truth per se, and in giving an honest account of how the participants in the project view themselves and their experiences* (Zuber-Skerrit, 2001: in press).

Ebbutt and Elliot (1985:11) mention that an action research study can be

*... judged to be internally valid if the author demonstrates that the changes indicated by his/her analysis of a problem constitute an improvement. Such an account would therefore need to contain not only an analysis of the problem but an evaluation of the action undertaken. An account can be judged to be externally valid if the insights it contains can be generalised beyond the situation(s) studied. An account can be internally valid but have no external validity, i.e. it can be judged as 'true' but entirely unique.*

In line with Zuber-Skerrit (2001), Feldman (1994) strongly argues that the focus for teacher-research<sup>3</sup> is shifted as the teacher as researcher is not attempting to measure outcomes or prove causality that should lead to generalisations, but to effect a change in the way that results in learners looking at the world in different ways. He continues and points out that this shift in focus alters the question of validity in action research. Specifically, Feldman (1994:97) notes that

*The validity of teachers' self-developmental action research arises from their discourses with their educational situations that leads to a change in their understanding of those situations. ... The teachers are coming to know the reality in order to transform it.*

Bransford *et al.* (1999:188) point out that *forms of validity that are appropriate to research in the practical domain, as in the case of action research, need to be acknowledged.*

The mentioned views on validity inevitably also touch on the notion of validity in qualitative research. In this regard Maxwell (in Cohen, Manion & Morisson, 2000:106) argues for the *need to replace the positivist notions of validity in qualitative research with*

<sup>3</sup>In this regard teacher-research is viewed as action research in an educational setting.

*the notion of authenticity* and points out that *understanding* is a more suitable term than *validity*. Maxwell (in Cohen *et al.*, 2000:107) proposes five kinds of validity in qualitative methods that define his views on "understanding", namely:

1. **Descriptive validity** refers to the factual accuracy of what happened in the research.
2. **Interpretive validity** refers to the ability of the research to interpret the meaning that the data has for the participants themselves.
3. **Theoretical validity** is the extent to which the research explains phenomena.
4. **Generalisability** here refers to generalising within specific groups and to specific outsider groups. In this regard internal validity has greater significance than external validity<sup>4</sup>.
5. **Evaluative validity** is the application of an evaluative framework and is judgemental of what is being researched.

With regard to the research reported in this thesis, it should be stressed that this study in essence reflects on a specific group of learners in particular circumstances. Furthermore, by the very nature of the developmental trend of the intervention, it cannot be assumed that the possible outcomes (awareness of thinking styles, changes in study orientation and successful grades) can solely be attributed to the specifics of the learning facilitation intervention of the support course. A developmental approach would fall very short of its aim if development was seen as restricted to a specific course strategy and outcomes. Therefore, personal and academic maturation of the learners is also a projected outcome of the learning facilitation strategy reported in this study. These are changes in learners that cannot be measured by questionnaires or tests as the latter only focuses on particular aspects of the learners' situations.

## 1.7 Research ethics

The matter of ethics is an important consideration in the present study<sup>5</sup>. The researcher accepts the assertion that research contributes to scientific knowledge and that human and technological advances are based on this knowledge. In particular, it is accepted that

---

<sup>4</sup> Internal and external validity are treated in Chapter 4, section 4.4.

<sup>5</sup> Ethical considerations with regard to research design are addressed in Chapter 4, section 4.3.

educational research should contribute to better the scholarship of teaching and the development of the learner. The researcher agrees with Mouton (2001:243) that

*Where research involves the acquisition of material and information provided on the basis of mutual trust, it is essential that the rights, interests and sensitivities of those studied must be protected.*

Due to the action research approach followed in this study, the students were viewed as essential participants in the research and not as merely 'experimental subjects'. Furthermore, the action research activities during 2000, 2001 and 2002 that are reported in this study were conducted as an integral part of the instructional approach followed in the POSC. Where the research methodology required the completion of questionnaires, this was treated as an integrated part of the course activities. Furthermore, the completion of the questionnaires was not compulsory and the students were assured that data would be treated anonymously and confidentially. In all, the researcher strongly honours each participant's right not to be harmed in any manner, physically, psychologically or emotionally.

Formal written permission for the research and the use and publication of the research data was obtained from the ethics committees of the School of Engineering and the School of Natural Sciences. Copies of these are given in Appendix A.

## **1.8 Overview and structure of the thesis**

In Chapter 1 a brief background is given of the domain in which the research for this thesis was done. The title is explained, the research approach followed in the study is outlined and the researcher's view on ethical considerations is highlighted.

Chapter 2 gives an epistemological overview of learning. The concept of brain-based learning and whole brain utilisation is viewed as a possible paradigm for elucidating learning in a support course in tertiary mathematics. Aspects of learning including meta-cognition, cooperative learning, constructivism, thinking styles, study orientation in mathematics and dimensions of intelligence are also discussed.

In Chapter 3 a theoretical basis for instructional design is given. Aspects of teaching derived from learning theories as well as from experiences in higher education are



discussed. A brain-based model for learning mathematics is proposed incorporating the aspects concerning learning discussed in Chapter 2. This model is taken as point of departure to design the learning facilitation strategy of mathematics for first year engineering students on a support course. It is suggested that teachers in higher education should take cognisance of the fact that instructional principles in higher education are increasingly being deduced from experiences based on concepts related to student learning as well as from research results which indicate that neuroscience and the functioning of the brain can contribute to insights in the facilitation of learning. The strategy for the learning facilitation followed in the Professional Orientation Support Course (POSC) is discussed.

Chapter 4 gives an overview of action research and the research design of this thesis. The validity and applicability of action research for the study are discussed. The data collection methods, procedures and instruments used in the study are discussed as well as the data processing procedures.

In Chapter 5 a detailed description is given of the action research cycles during 2000, 2001 and 2002 that were done in the School of Engineering at UP and which form the main focus of this thesis.

In Chapter 6 a quantitative and qualitative analysis of the research results of the 2000, 2001 and 2002 research studies are given.

In Chapter 7 the focus is on determining whether the aim of the research has been met. The proposed learning facilitation strategy is summarised, the results presented in Chapter 6 are discussed and the effects of the implementation of the learning facilitation strategy on study orientation and mathematics performance are discussed. Insights gained during the study are summarised and possible areas for further research are identified

Figure 1-4 on the following page gives an overview of the thesis and the structure thereof.

Figure 1-4 Overview and structure of the thesis

