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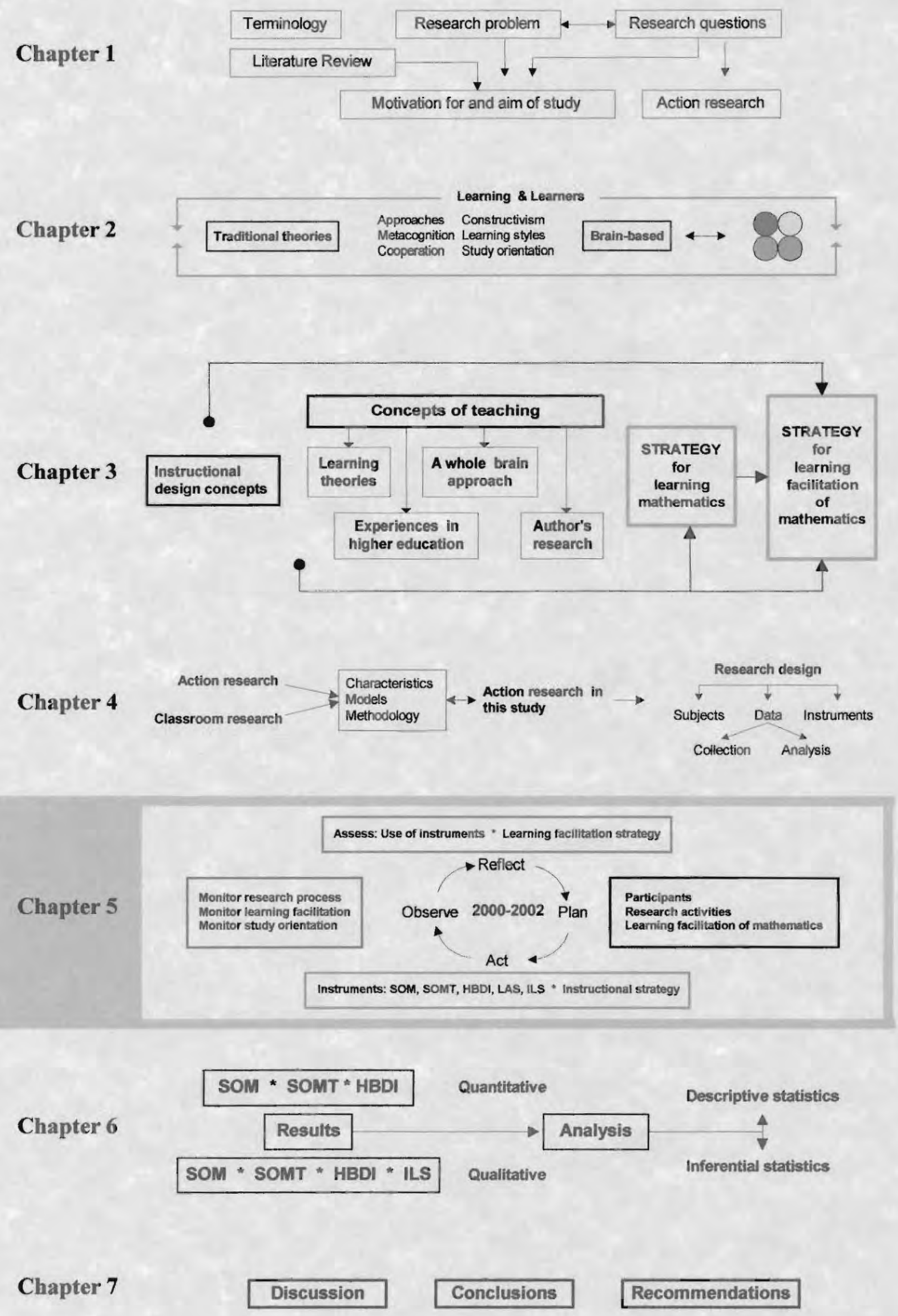

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Research studies 2000-2002

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Chapter 5

Research studies 2000 – 2002

5. Introduction

In November 1999 the author joined the Five Year Study Programme (5YSP) in the School of Engineering as lecturer responsible for the Professional Orientation Support Course (POSC). This posed the opportunity to implement strategies that are based on experiences and results gained during the author's involvement with students in the School of Science since 1991 and research conducted during 1993-1999 in the Gold Fields Computer Centre for Education in the School of Science. Selected results of these research studies have been reported by Steyn (1998), Steyn and De Boer (1998), Steyn, Carr and De Boer (1999) and De Boer and Steyn (1999).

In order to place the action research studies during 2000, 2001 and 2002 in context, an overview is firstly given of the 5YSP, the admission requirements for engineering study at the University of Pretoria and the POSC.

5.1 The Five Year Study Programme

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 5YSP was introduced in the School of Engineering at the University of Pretoria. This programme increases the duration of the standard engineering study from four to five years. This is arranged in such a way that the academic courses of the first two years of the regular four year 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 who are academically at risk because of their educational background.

The data in Table 5-1 summarises the retention of black students on the 5YSP during 1994 to 2001 (Du Plessis, 2001; Du Plessis, 2002).

Table 5-1 Retention of black students on the 5YSP during 1994-2001

Year of enrolment	1994	1995	1996	1997	1998	1999	2000	2001
Number of students	21	55	55	23	25	36	34	45
POSC students	21	55	55	23	25	36	33	40
Graduated in 5 years		2	3	3				
Graduated in 6 years	1	7	7					
Graduated in 7 years	1	4						
Registered for engineering in 2002	1 (5%)	1 (2%)	5 (9%)	7 (30%)	13 (52%)	18 (50%)	30 (88%)	40 (88%)

The total admissions of black students for engineering study during 1994-2001 is 294. Of these students 28 (18%) out of a possible 154 (representing the 1994-1997 intake) have graduated. In 2002, 115 students (39% of the 1994-2001 intake) are still registered for engineering and 151 students (51% of the 1994-2001 intake) have either migrated to another faculty or discontinued their studies. Most of the black students on the 5YSP are also enrolled for the POSC.

From the data it is noticeable that the retention rate of black students on the 5YSP is increasing, for example, from the 1998 intake a possible 52% of the students may graduate in the minimum five years.

The figures in Table 5-1 give an indication for the need of support to increase the tertiary survival of prospective black African graduates in engineering. Du Plessis and Quagraine (2000:27) point out that *a mere extension of the period of study has proved to be only partially successful. A more holistic approach to the needs of the student at risk in engineering seems imperative.* According to Du Plessis and Quagraine (2000) engineering educators in South Africa should reconsider what they want to achieve; cognisance must be taken of the diverse educational, social and environmental factors that influence academic achievement and special plans of action should be taken to secure academic success of prospective (black) engineering students.

The focus of the research presented in this thesis specifically addresses one of the cornerstones of engineering study namely the thorough understanding of the fundamental concepts underpinning a study of calculus. The learning facilitation strategy for mathematics proposed in this thesis can thus be viewed as a reconsideration of the structure of support for mathematics in a first course in calculus. In this way the research supports the afore mentioned views of Du Plessis and Quagraine (2000) regarding engineering education.

5.2 Admission requirements for engineering study at UP

During 1994-2002 the admission requirements for engineering study at the UP are a minimum M-score of 18 and a score of at least 60% (C-symbol) for both Mathematics and Physical Science on Higher grade in the final examination in Grade 12. The M-score is calculated according to the values given in Table 5-2. If a candidate does not comply with these requirements but has minimum M-score of 12 as well as one of the combinations given in Table 5-3, he/she may be permitted to write an admission test. The system of writing an admission test was introduced in 1996.[63] Admission to the 5YSP is then considered on ground of the results of the test (School of Engineering Regulations and Syllabi, 2001).

Table 5-2 Calculation of M-score at the University of Pretoria

Symbols	Higher Grade	Standard Grade
A-symbol (80% and higher)	5	4
B-symbol (70%-79%)	4	3
C-symbol (60%-69%)	3	2
D-symbol (50%-59%)	2	1
E-symbol (40%-49%)	1	0

[63] Referring to Table 5-1 on the previous page, it should be pointed out that the decline in numbers of enrolment between 1996 and 1997 may be due to the implementation of the admission test and more stringent admission requirements (Du Plessis, 2002).

Table 5-3 Alternative combinations of scores for admission to the Five Year Programme

Grade 12 Mathematics (Higher grade)		**Grade 12 Physical Science** (Higher grade)		**M-score**
D-symbol	+	D-symbol	+	12
A-, B- or C-symbol	+	D-symbol	+	12
D-symbol	+	A-, B- or C-symbol	+	12

5.3 The Professional Orientation Support Course (POSC)

Throughout their study, students on the 5YSP enrol for the same courses as students on the 4YSP and they attend the same classes. However, all the students on the 5YSP are given additional academic support in their first year engineering courses by means of a tutoring system. Tutors are usually senior (engineering) students who are appointed by the School of Engineering. The supervision of tutors is the responsibility of the lecturers who teach the courses where the tutoring is done.

In spite of this tutoring support, some of the students enrolled for the 5YSP are still at risk due to the fact that in the late 1990s early 2000s secondary schooling in South Africa represents varying levels of educational competency. In order to accommodate these varying levels of competency in educational background a two semester credit-bearing course,[64] the POSC, has been presented as part of the 5YSP since 1994.

The POSC is presented as two semester modules during the first year of study. The module code in the first semester is JPO110 and in the second semester it is JPO120. Students obtain eight credits[65] for each of the modules. The aims of the POSC are to provide learning opportunities for the development of academic, personal, communication and information skills within an engineering context and to facilitate students' competency in mastering the fundamental concepts that underpin a study in calculus. In pursuing these

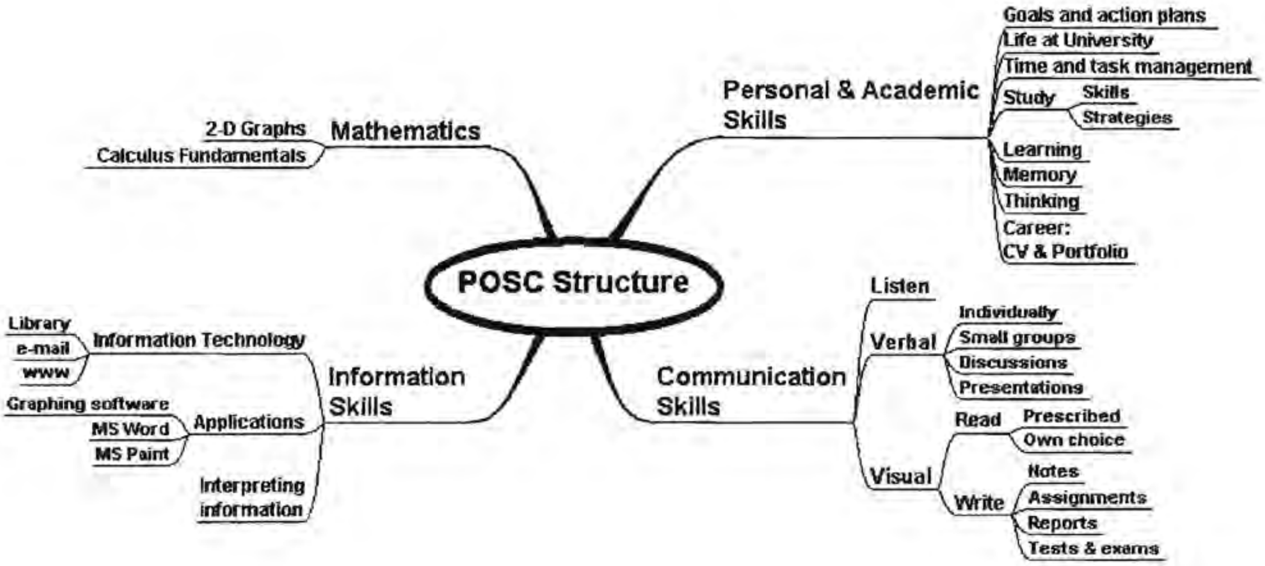
[64] Since 2001 the term "module" is used instead of "course". For the purpose of this thesis the term "module" is also used for the two modules comprising the POSC.

[65] Eight credits is a regular weighting for a semester module in the School of Engineering at UP although some modules, such as the standard first semester calculus module, have a higher weighting – the credit weighting for this calculus module is 16.

aims the primary focus is the development of each student's academic potential in order for him or her to pursue engineering studies successfully.

The diagram in Figure 5-1 gives an overview of the structure of the POSC as it was presented during 2000, 2001 and 2002. The content of the course focuses on two broad themes, namely the development of skills and mathematics.

Figure 5-1 Overview of the Professional Orientation Support Course (POSC)



Compiled by the author of this thesis

In complying with the outcomes based educational policy of South Africa in the early 2000s (Department of Education, 1995 & 1997; Olivier, 1998), the two themes, skills development and mathematics, can be interpreted in terms of **general (critical) learning outcomes** as follows.

1. Organising and managing own activities responsibly and effectively.
2. Working effectively with others as a member of a group and a class.
3. Communicating effectively using visual, mathematical and/or language skills in the modes of oral and/or written persuasion.
4. Collecting, analysing, organising and critically evaluating information.

5. Using science and technology effectively and critically, showing responsibility towards the environment and health of others.
6. Contributing to the personal development of the learner.

The general (critical) outcomes of the educational policy in South African are complemented by **specific learning outcomes** (Olivier, 1998). The following **specific learning outcomes** result from the activities of the POSC course.

To reach the specific learning outcomes for the **mathematics component** of the POSC, students

1. Revise fundamental mathematical concepts.
2. Identify possible gaps in their own mathematical background.
3. Use the graphing software package *Master Grapher for Windows*
4. Visualise 2-D mathematical functions through their graphs using *Master Grapher for Windows*.
5. Explore and interpret the characteristic features of 2-D functions using a graphical representation.
6. Identify when they do not understand concepts introduced in their main stream mathematics courses.
7. Clarify (on the own and/or with the help of others) those concepts that are unclear.
8. Understand the fundamental mathematical concepts that underpin a study of calculus.

With regard to the specific learning outcomes for the **skills components** of the POSC, students overall learn to

- Think and function within an academic, engineering environment.
- Use the English language to communicate effectively.
- Solve problems from a scientific point of view.
- Use technology to access, process and present information effectively.

Following are specific learning outcomes resulting from the different skills categories.

With regard to specific learning outcomes for **personal skills** students learn to:

1. Set goals for personal development and focus on achieving these goals.
2. Develop and maintain healthy interpersonal relationships.

3. Develop a realistic self-concept and an understanding of one's personal strengths and weaknesses.
4. Gather the relevant information, seek help and support from people within and outside of one's immediate circle, in order to make decisions and solve problems on a personal level.
5. Apply the principles of effective task management.
6. Develop and maintain a healthy, balanced lifestyle.

With regard to specific learning outcomes for **communication skills** students learn to:

1. Listen actively to the statements of fellow students, lecturers and experts in such a way that promotes effective communication.
2. Read attentively the statements of fellow students, lecturers and experts as presented in reports, notes and textbooks.
3. Express one's knowledge and ideas in unambiguous English, using correct grammar and the terminology that is customary in the fields of engineering.

With regard to specific learning outcomes for **information skills** students learn to:

1. Use the Microsoft WINDOWS operating system to manage applications and files.
2. Use application software including graphing software, word processing and a spreadsheet.
3. Use information technology to access and process information.

The development of observation skills and problem solving skills within an academic and engineering content are integrated within the learning content and the learning process of the course. The specific learning outcomes associated with these are subsequently given.

When performing the tasks in the POSC course, the following specific learning outcomes relate to **observational skills**:

1. Giving oral and/or written descriptions of scientific or technological phenomena, theories and methods and distinguishing the facts described.
2. Analysing scientific information for relevancy in terms of the following:
   - Comprehensiveness – showing what information is lacking or superfluous.
   - Accuracy – showing whether the information used is sufficiently accurate.
   - Significance – showing that the information is significant.

3. Establish the meaning of scientific information in terms of the following:
   - Valid deductions that can be made from the information.
   - Logical steps that lead to each deduction.

When given a problem in the POSC (and eventually in engineering practice), students must demonstrate their ability regarding the specific learning outcomes relating to **problem solving skills** and act as follows:

1. Identify the problem.
2. Generate one or more alternative solutions to the problem.
3. Distinguish between relevant and superfluous information and identify additional information to be gathered.
4. Evaluate the alternatives with regard to what is given and what is required and select the best solution.
5. Implement the solution.
6. Evaluate the solution.

Emphasis in the POSC course is on the **learning content** as well as on the **learning process**. It is imported to note that, where possible, an integrated approach is followed in the presentation and assessment of the course content. This is done in order to give the students an idea of the skills and knowledge an engineer needs in a real world situation. For example, when the students do a project during the second semester, they have to do research and use technology (information skills), they have to apply mathematical knowledge (academic skills) and have to compile a report (communication and information skills). Observational and problem solving skills are a vital part of the activities. Furthermore, working in small groups and using time effectively are just some of the other skills needed and practised for the successful completion of the project.

The learning facilitation philosophy of the POSC indeed exhibits the view expressed by Olivier (1998:39), namely that:

> *The challenge involved in outcomes-based learning is the rationale of achieving outcomes within a learning programme while developing within learners the capability to think, reason, criticise, deliberate, think, socialise and apply knowledge and skills within a specific context, rather than just acquiring it ... there is a strong focus on conceptual thinking, problem solving and insight abilities, which is coupled with strong adaptability to change and develop. This approach implies that the ways learning take place are as important as how mastering and integrating and manipulating information take place or occur.*

In addition to complying with the general educational policy in South Africa of outcomes-based learning, the training of engineers in South African also have to comply with outcomes set by ECSA. These outcomes are summarised in Table 5-4. Those outcomes that are specifically addressed in the POSC (with relevance to the course content of the POSC) are indicated with a tick mark.

Table 5-4 Engineering degree outcomes required by ECSA

	ECSA outcomes	Addressed in the POSC
1	An ability to identify, formulate and solve engineering problems.	✓
2	An ability to apply knowledge of mathematics, science and engineering.	✓
3	An ability to design a system, component or process to meet desired needs.	
4	An ability to apply research methods, plan and conduct investigations and experiments	
5	An ability to use appropriate engineering methods, skills and tools and assess the results they yield.	✓
6	An ability to communicate effectively, both orally and in writing, with engineering audiences and the community using appropriate structure, style and graphical support.	✓
7	A broad education necessary to understand the impact of engineering activity on the society and the environment.	✓
8	An ability to function as an individual and as a team member in a multidisciplinary environment.	✓
9	An ability to engage in life-long learning through well developed learning skills.	
10	To be critically aware of the need to act professionally and ethically and to take responsibility within own limits of competence.	✓

Compiled from ECSA Document PE-61 (1998)

Due to the extent of the scope of the learning facilitation activities in a support course such as in the POSC outlined above, the opportunities for utilising learning facilitation as action research endeavours are abundant. The focus in this thesis is therefore narrowed to the development of a learning facilitation strategy for mathematics. As the learning facilitation of mathematics is the primary focus in the POSC during the first semester, the action research reported in this thesis concerns the activities of the first semester module, JPO110, of the POSC. For the purposes of this thesis the action research activities during 2000 and 2001 are the main focus. During 2002 a limited action research study was also conducted with a restricted focus on two aspects that were also addressed in the 2000 and 2001 studies. This included the implementation of the SOMT both as a pre-intervention instrument at the beginning of the POSC and as a post-intervention instrument after the POSC. These results are quantitatively and qualitatively analysed together with the comparable results for 2000 and 2001. Furthermore, the ILS was also implemented in 2002 and the results hereof is qualitatively analysed together with those of 2001.

In sections 5.4 to 5.8 the research studies of 2000 and 2001 are detailed. The research study of 2002 is discussed in section 5.9.

5.4 Overview of the 2000 and 2001 research

The diagram in Figure 5-2 illustrates the action research cycles of 2000 and 2001 and indicates that the research is based on the results and insights gained from the 1993-1999 research activities. For the purpose of this chapter the action research terms of **act**, **observe** and **reflect** are interpreted as **implement**,[66] **monitor**[67] and **assess**[68] as these, in the opinion of the writer, convey the essence of the research activities reported in this thesis.

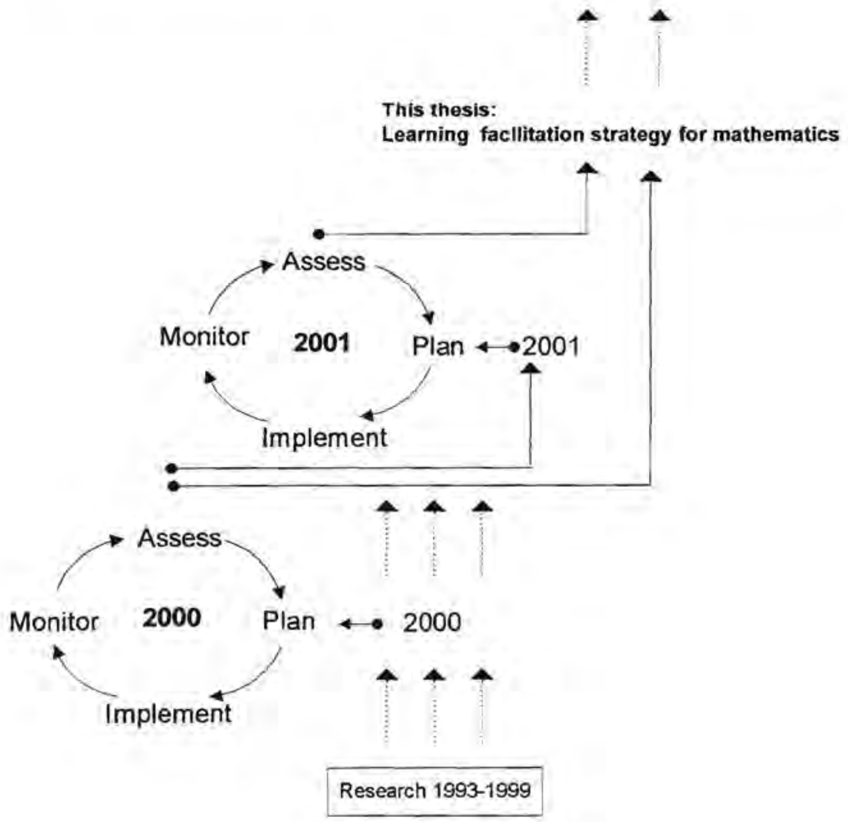
Two aspects regarding the format in which the action research activities are reported here need to be pointed out. Firstly, the details of the research activities of 2000 and 2001 regarding the POSC students are reported simultaneously as most of them were similar in scope. Wherever differences, changes or adaptations occurred between the activities of 2000 and 2001, they are indicated and treated separately. Secondly, the level of detail in which the action research activities are reported was determined by identifying those

[66] The term "implement" is viewed as *to put into effect* (Thompson, 1995:681).
[67] The term "monitor" is viewed as *to watch and check something over a period of time* (Crowther, 1995:753).
[68] The term "assess" is viewed as *to determine the importance, size or value* (Woolf, 1977:67).

principles and activities that can be regarded as essential information for any other interested researcher who may wish to duplicate the study or an aspect thereof.

In Figure 5-3 an overview is given of the content of the phases plan, implement, monitor and assess of the action research cycles.

Figure 5-2 Action research cycles 2000 and 2001



Compiled by the author of this thesis

Figure 5-3 Action research activities 2000 and 2001

Compiled by the author of this thesis

In Chapter 4 (Table 4-1) some general characteristics of action research were listed. All of these characteristics except one, namely collaborating with other researchers, are relevant to the present study. With regard to the necessity of collaboration, Cohen and Manion (1994) point out that collaboration in action research is not essential and Zuber-Skerritt (1992b; 1997) strongly argues that teachers in higher education themselves should conduct action research on their own teaching practices. The characteristics of the action research activities as applicable to this study are summarised in Table 5-5.

Table 5-5 Common characteristics of action research in the current study

1 Situational	This study is concerned with learning facilitation in a specific context and attempting to explore it in that context.
2 Collaborative	This study did not involve teams of practitioners and researchers.
3 Participatory	In this study the researcher is not an outside expert conducting an enquiry with 'subjects', but a co-worker doing research with and for the learners concerned.
4 Critical	In this study participants (lecturer and learners) search for practical improvements in their work and strive to change their environment as necessary and they themselves are changed in the process.

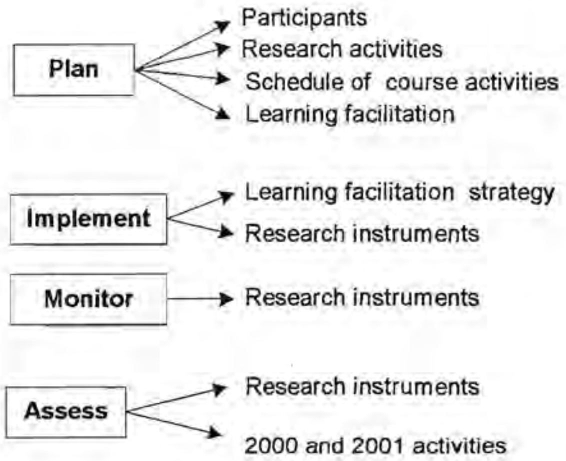
5 Self-evaluative	In this study adaptations are continuously being evaluated and the ultimate objective is to improve practice in some way or other.
6 Accountability	In this study the researcher (lecturer) remains committed to continuous quality improvement that is fostered by the nature of the action research approach.
7 Practical and theoretical	This study seeks to unite two central concerns in educational research, namely improvement in practice and increased knowledge.
8 Interpretative	This study is not assumed to result in the researcher's positivist statements based on right or wrong answers to the research questions, but in contributions to improve learners' experience in mathematics based on the interpretation of the outcomes of the study.
9 Research into teaching	This study is action research conducted by the practitioner on the own teaching practice and is also informed by theory, but not confined by abstract theories.
10 Professional development	In this study the researcher is truly involved in educational research on which the own practice is based and the study contributes to the professional development of the researcher.
11 Continuous	The task is not finished when the report on the research activities of 2000-2002 has been documented in this thesis. Improvement of support in learning facilitation of tertiary mathematics in a support course is an ongoing process.

Compiled by the author of this thesis and based on the contents of Table 4-1 on pages 138-139

In the following section the planning phases of the 2000-2001 research are discussed. Then the schedules for the implementation of the activities are given and finally the remaining three phases (implement, monitor and assess) are discussed.

The report on the phases implement, monitor and assess are treated in the following way. Firstly the implementation of the learning facilitation strategy for mathematics (proposed in Chapter 3) is discussed. Then the implementation of the research instruments and the monitoring thereof are discussed. The final phases of the research cycles are discussed by assessing the 2000 and 2001 studies with regard to the instruments used and the effect of the learning facilitation strategy that was followed. The diagram in Figure 5-4 illustrates the structure of this discussion.

Figure 5-4 Structure of the discussion of action research activities in 2000-2001



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5.5 Planning the 2000 and 2001 research

The action research studies during 2000 and 2001 were conducted as an integral but unobtrusive part of the POSC. During everyday course activities students were not deliberately made aware of the fact that they were participating, together with the lecturer, in an action research study. Exceptions to this were when questionnaires were administered or surveys conducted. In these cases the lecturer (researcher) explained to the students that their contributions would, on the one hand aid research to improve the instructional approach of the POSC and on the other, their participation could enhance their own personal and academic development. It should be borne in mind that although the focus in this thesis is on the **development of the mathematics potential** of the learners, the overall challenge of learning facilitation in the POSC is to develop the academic potential of the learners.

The activities undertaken to plan the research (and structure the POSC) are listed Table 5-6 for 2000 and in Table 5-7 for 2001.

Table 5-6 Action plan 2000

Planning	Activities	
Course schedule	Plan POSC activities according to the schedule on the official timetable Schedule SOM[69] (Pre intervention, paper based) Schedule HBDI[70] (Computer based online) Schedule LAS[71] (Paper based)	
Research schedule	Semester 1:	SOM administer SOM feedback HBDI online
	Semester 2:	LAS administer LAS feedback HBDI feedback SOMT (Computer based) [72]
	Qualitative assessment:	Researcher's self-reflection Student feedback
	Quantitative assessment:	HBDI LAS instead of HBDI? SOM and SOMT (Pre- and post-intervention) WTW 114
Computer and lecture facilities	Reserve computer laboratory for all scheduled periods Reserve lecture hall for all schedules periods	
Facilitation aid	Search for and appoint tutors who are able and committed to the aims of the POSC	
Instructional material	Acquire a copy of the instructional package *Fundamentals of 2-D Function Graphing* for each student Compile the study manual for the POSC	
Course assessment[73]	Continual assessment throughout Weekly marking of mathematics answer sheets Class tests (paper based) and using the graphing utility *Master Grapher* Semester 1 (JPO110): No formal semester tests, June exam Semester 2 (JPO120): No formal semester test, November exam	
Questionnaires	Adapt SOM HBDI online Adapt the LAS	

[69] See Chapter 4, section 4.6.4 for information on the SOM.
[70] See Chapter 4, section 4.6.6 for information on the HBDI.
[71] See Chapter 4, section 4.6.7 for information on the LAS.
[72] Although this activity was done in 2001, the results thereof pertain to the 2000 study and thus the inclusion of it in this table.
[73] The mathematics component of the POSC in the first semester counts 65% of the total mark for this module. The other 35% is allocated to skills development and introductory research activities.

Table 5-7 Action plan 2001

Planning	Activities	
Course schedule	Plan POSC activities according to schedule on official time table Schedule SOM (Pre intervention, paper based) Schedule LAS (Paper based) Schedule ILS[74] (Paper based) Schedule SOMT[75] (Post-intervention, computer based)	
Research schedule	Semester 1:	SOM administer LAS administer ILS administer Individual feedback on all the questionnaires
	Semester 2:	SOMT administer SOMT feedback
	Qualitative assessment:	Researcher's self-reflection Student feedback
	Quantitative assessment:	SOM and SOMT (Pre- and post-intervention) WTW 114 marks
Computer and lecture facilities	Reserve computer laboratory for all scheduled periods Reserve lecture hall for all schedules periods	
Instructional material	Acquire a copy of the instructional package *Fundamentals of 2-D Function Graphing* for each student Edit and adapt the 2000 Study Manual of the POSC for 2001	
Facilitation aid	Search for and appoint tutors who are able and committed to the aims of the POSC	
Course assessment	Continual assessment throughout Weekly marking of mathematics answer sheets Semester 1 (JPO110): No formal semester tests, June exam Semester 2 (JPO120): Two semester test during scheduled test week, no November exam	
Questionnaires	SOM Adapt SOM for tertiary students (referred to as SOMT) Adapted LAS ILS	

[74] See Chapter 4, section 4.6.8 for information on the ILS.
[75] See Chapter 4, section 4.6.5 for information on the SOMT.

5.5.1 Participation

The participation in the action research activities during 2000 and 2001 mainly involved the researcher and the students enrolled for the POSC. During 2000 the research activities also involved a group of first year civil engineering students. Their inclusion in the research concerned comparing the thinking style preferences the engineering students on the POSC to those of a group of first year civil engineering students (in the School of Engineering).

It should be pointed out that an additional set of data concerning thinking style preferences and study orientation is also included in the results given in Chapter 6 and discussed in Chapter 7. This data on thinking style preferences is from a study in 1998 (De Boer & Steyn, 1998) concerning the thinking style preferences of a group of science students on a support course (in the School of Natural Sciences) and it is used in the current report to compare the thinking style preferences of these science students to those of the engineering students mentioned above.

In the following sections detail is only given of the POSC students as their involvement form the main focus of the current study.

5.5.1.1 Participants of 2000

The POSC class of 2000 comprised 33 students in the first semester of whom five were females and 31 were black. An African language is the mother tongue of 31 students and Afrikaans the mother tongue of two students. English is the second (or third) language of all the students. The language of instruction for mathematics in secondary school was English for 21 of the students, 8 received instruction in English as well as in their mother tongue and four received instruction in their mother tongue. The average M-score of this group was 17.9 out of a possible 30.

Only 19 of the students had had limited previous experience with computers and none of them had used a computer for mathematics before. This limited experience comprised, on average, one to two hours of computer use that was scheduled as a computer literacy period in the formal school timetable in their final year of secondary schooling.

All 33 students completed the HBDI and 32 completed the adapted LAS. The adapted SOM was completed by 30 of the students and 26 students completed the SOMT.[76]

These identifying attributes of the POSC participants in 2000 are summarised in Table 5-8.

In addition to the POSC students, 30 first year civil engineering students also completed the HBDI and the LAS questionnaire during 2000.

5.5.1.2 Participants of 2001

The POSC class of 2001 comprised 40 students in the first semester of whom 13 were females. During the second semester there were 38 students including the 13 females. All the students were black. An African language is the mother tongue of 37 students, English is the mother tongue of two students and one student has Portuguese as mother tongue. English is the second (or third) language of all but two students. The language of instruction for mathematics in secondary school was English for all the students. The average M-score of this group was 17.1 out of a possible 30.

Of these 40 students, 17 had had no previous exposure to computers. Twenty students indicated that they had had previous experience with computers that was limited to introductory usage skills, some word processing and spread-sheet use.[77] Three students indicated that they had computers at home of which two have Internet access. Again none of the students had used a computer for mathematics before.

The HBDI was not used in the 2001 study but all the students completed the LAS as well as the ILS. The SOM was done by 40 students and all 38 students enrolled for the second semester completed the SOMT.

The identifying attributes of the POSC participants in 2001 are summarised in Table 5-8.

[76] For the discussion in this chapter, no distinction is made between the different versions of the SOMT.

[77] Although the students with 'limited' computer knowledge indicated that they had skills with regard to word processing and spreadsheet use, the researcher found during course activities in the second semester of both 2000 and 2001 that none of these students were proficient users of any application program.

Table 5-8 Attributes of the POSC participants of 2000 and 2001

	Number of students		
	2000	2001	Total
Male	28	27	55
Female	5	13	18
Total per group	33	40	
Mother tongue:			
African language	31	37	68
Afrikaans	2	0	2
English	0	2	2
Portuguese	0	1	1
Language of high school instruction in mathematics:			
English	20	40	61
Mother tongue	4	0	4
English and mother tongue	8	0	8
Average M-score:			
	17.9	17.1	
Computer experience prior POSC enrollment:			
No experience	14	17	31
Limited experience	19	20	39
Experience	0	3	3
Used for mathematics	0	0	0
Participation in the:			
Herrmann Brain Dominance Instrument (HBDI)	33	0	33
Lumsdaine and Lumsdaine Learning Activity Survey (LAS)	32	40	62
Felder Solomon Index of Learning Styles (ILS)	0	40	40
Study Orientation Questionnaire in Mathematics (SOM)	30	40[78]	70
Study Orientation Questionnaire in Mathematics Tertiary (SOMT)	26	38[79]	62

[78] Of these 38 could be used for data analysis.
[79] Of these 36 could be used for data analysis.

5.5.2 Planning the research activities

Research activities were planned to address the research questions stated in Chapter 1.[80]

The research questions were explored and assessed against the background of the learning facilitation strategy followed in the POSC and within the context of the activities of the course. In order to explore the first two and the last research questions, appropriate instruments had to be chosen.[81]

The aim of the first research question was to explore the study orientation of the students towards mathematics. For this purpose the SOM and the version adapted for tertiary students, the SOMT[82] were used.

In the second research question the aim was to determine if the learning facilitation strategy followed in the support course has an effect on students' study orientation towards mathematics. In this case the results of the SOM (SOMT) as pre-intervention and post interventions are quantitatively and qualitatively compared.

In addressing the fourth research question, concerning the thinking style preferences of the students, the HBDI, the LAS and the ILS were used.

The third research question explores whether a learning facilitation strategy using graphical exploration of 2-D functions to enhance the learning of mathematics contributes to improved academic performance in the standard first semester course in calculus. This question addresses the performance of the POSC students in the standard calculus course compared to the performance of other students on the 5YSP who are not enrolled for the POSC and to the performance of students on the regular 4YSP.

5.5.3 Schedule of course activities

The diagram in Figure 5-1 on page 190 outlines the focus areas of the POSC. During the module in the first semester the primary focus is on mathematics. However, the learning facilitation strategy proposed in this thesis strongly advocates the development of the **mathematics potential** of the learner and this inevitably also involves the development of **personal, academic and communication skills**. The development of these skills is

[80] The research questions are stated in Chapter 1 section 1.4 on page 8.
[81] See Chapter 4 for details on the instruments used in this research.
[82] The adaptation to the SOM for tertiary use is discussed in Chapters 4 and 6.

therefore integrated into the learning facilitation strategy of mathematics in the POSC. Furthermore, the instructional material used for the learning facilitation of mathematics in JPO110 heavily relies on the use of a computer to generate the graphs of two-dimensional functions and this necessitates the acquisition of basic skills in the use of a computer and the graphing program *Master Grapher for Windows* (Carr & Steyn, 1998).

In scheduling the action research activities reported in this thesis as well as the course activities of JPO110 during 2000 and 2001 the researcher (lecturer) had to incorporate the administering of the questionnaires for the purposes of the research into the course activities in such a way that they would be appropriate for the course content and had to be given at a time when students would realise the need thereof and could benefit from the resulting information.

During 2000 a total of 60 periods of 50 minutes each was available for JPO110 and in 2001 there were 62 periods. In Table 5-9 the allocation of the periods to different course and research activities is summarised. For the purposes of this thesis it should be pointed out that 24 periods were scheduled for mathematics in 2000 whereas 33 periods were scheduled for mathematics in 2001. The number of periods used for academic and personal skills were almost equal (eight in 2000 and seven in 2001). Five periods were used for administering the research instruments in 2000 and four periods in 2001. In both cases the students had to do the SOMT questionnaire in their own time.

Table 5-9 Allocation of periods to the activities of the POSC during 2000 and 2001

	2000	2001
Total number of periods available	60	62
Total periods used for:		
Administrative and social matters	6 + 2	4 + 1
Hands on introduction to computer use	1	1
Mathematics, using computer graphing utility	20	30
Mathematics pen & paper	2	3
Mathematics test	2	0
Personal & academic skills	6	5
Additional skills	11	12
Mind Map video & information	2	2
Research questionnaires	5	4
Group feedback on questionnaires	3	0

It should be noted that the initial aim during the first four weeks of the first semester is to get the students doing the mathematics of the POSC as soon as possible and at the same time give them the basic skills to cope with the new academic environment. This is done to support them in their preparation for the first test week of the School of Engineering that is usually in the beginning of March.

During both the 2000 and 2001 research activities the administering of the research questionnaires was scheduled for the time between the first and second test weeks. In 2000 the SOM was scheduled in the week following the first test week. The HBDI was scheduled for the second week after the March-April recess. The LAS questionnaire was scheduled for the beginning of the second semester in mid July. The POSC 2000 students did the SOMT in June 2001.

In 2001 the SOM was also the first research instrument to be administered and was scheduled for the second week following the first test week. The LAS questionnaire was scheduled for the following week. The Felder Solomon ILS was scheduled for the week following the March recess. The SOMT was scheduled in the second semester at the beginning of September.

An information session on mind maps as a study tool was scheduled after the students had had some experience preparing for tests at university. In 2000 it was scheduled after the two test weeks but prior to the June exam. In 2001 the information on mind mapping was scheduled for the end of April after the first test week and prior to the second test week.

5.5.4 Planning the learning facilitation of mathematics in the POSC

Students who are enrolled for the POSC attend the same standard mathematics courses as the other first year engineering students. All the students enrolled for the standard calculus course during the first semester (coded as WTW114 during 2000-2001 and as WTW158 in 2002) have four 50 minute lecture periods and one 90 minute practical session per week. In addition to the lectures and practicum all the engineering students on the 5YSP (including the POSC students) attend two compulsory tutor sessions of 50 minutes each per week. These sessions are scheduled to fit into students' free lecture periods. Tutors[83] conduct the sessions and approximately ten students are allocated to a specific tutor. Students should preferably remain with the same tutor. These activities are presented and coordinated by the Department of Mathematics.

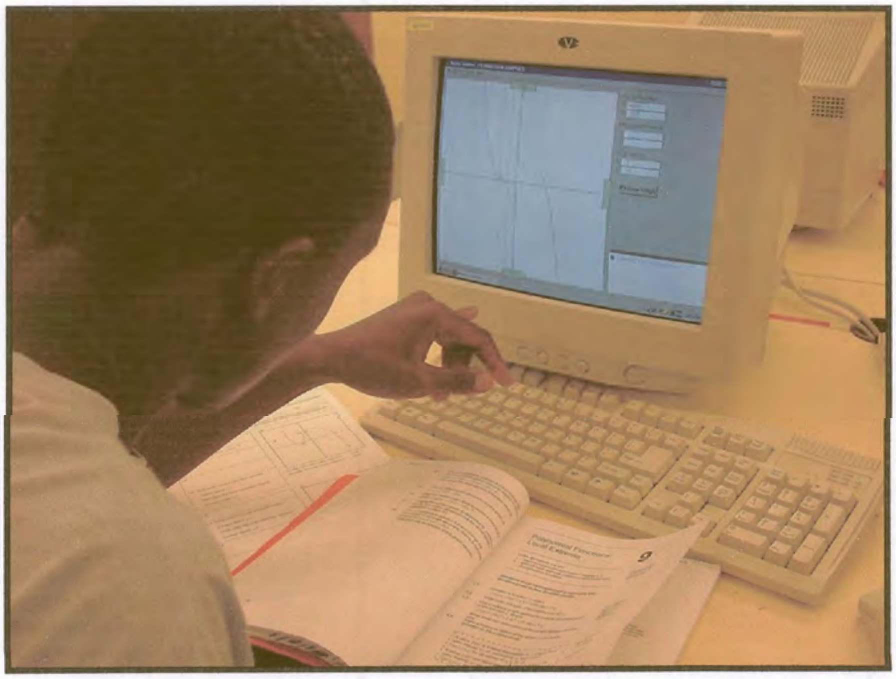
The mathematics component of the POSC is done independently from the standard calculus course but in addition to the above mentioned activities. The aim of the mathematics activities in the POSC is to ensure that students understand two-dimensional functions and their graphs as the fundamental concepts that underpin a study in calculus are embedded in a thorough understanding hereof (Finney, Thomas, Demana & Waits, 1994; Larson, Hostetler & Edwards, 1998).

The mathematical content of the POSC (in the module JPO110) includes the principles from pre-calculus that underpin a study of calculus, concepts related to the Cartesian coordinate system, two-dimensional functions, the concepts of limit, continuity and differentiation, the application of the first and second derivative and estimating the area under a curve. Figure 5-5 and Figure 5-6 illustrate the mathematic activities of the POSC.

[83] See section 5.1 above for information on the tutoring system.

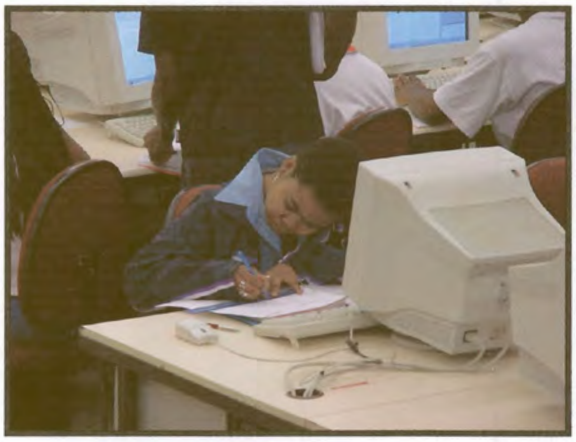
Figure 5-5 Mathematics activities in the POSC

Mathematics activities in the POSC take place in a computer laboratory which is illustrated in the photograph above. Exploration of mathematical concepts related to 2-D functions is done using a computer graphing tool, following structured activities in a work book, analysing the graphs of 2-D functions, making deductions and writing down answers on a formatted answer sheet. The photograph below illustrates a student engaged in these activities.



The following photographs illustrate three typical aspects of the learning facilitation strategy proposed in this thesis and followed in the POSC. Students work alone, there is frequent one-on-one interaction between facilitator and learner and students also engage in informal small group discussions for short periods.

Figure 5-6 Learning facilitation activities in the POSC



Student working alone.

One-on-one tutor and learner interaction.

Informal small group activities.

5.6 Implementing the learning facilitation strategy for mathematics

The diagram in Figure 5-9 on page 218 illustrates the implementation of the learning facilitation strategy proposed in this thesis. In the following sections the main aspects of the implementation activities, namely the tasks of the facilitator, the instructional media and the learning facilitation strategy are discussed.

5.6.1 Tasks of the facilitator

The following tasks of the facilitator are singled out and briefly discussed as they are specifically relevant for the learning facilitation of mathematics in the POSC. The tasks of the facilitator are associated with the implementation of "Learning Facilitation" as illustrated in Figure 5-9 on page 218.

The tasks of the facilitator include overseeing that the following principles, identified by Steyn (1998) for learning facilitation when a graphing utility is used, are addressed and implemented.

- **Structured exploration and interpretation**. Graphical explorations as an aid to mastering fundamental mathematical concepts need to be well structured. Learners need to be taught how to explore graphs and make meaningful interpretations. Disregarding this principle may result in graphical images becoming only 'nice to look at' and learners perceiving them as 'so what about it'. In order to structure learners' exploration activities, detailed step-by-step guidelines for the exploration activity need to be followed. The example in Appendix B illustrates the format of a worksheet that complies with this principle. The step-by-step instructions imply that students have to read, comprehend and use this instructional information to do the exploration activities. This promotes self-exploration by a learner and the activity is self-paced.

- A **whole brain approach** encompasses a combination of graphical exploration and graphical analysis that can be interpreted as a back and forth movement between right and left brain activities.[84] Using the principle of structured exploration discussed above, and in particular, working through worksheets as in Appendix B, results in activities where the utilisation of cognitive functions, associated with the linear hemisphere, are promoted through the structured format and verbal information. This is followed by the utilisation of

[84] See Chapter 2 Table 2-7 on page 63 for key brain characteristics, note the explanation of the "iterative" characteristic.

cognitive functions associated with global hemisphere in the actual exploration activity, which is then followed by linear hemisphere utilisation in analysing, formulating and writing down of the solutions to the problem. The incorporation of both exploration and analysis contribute to the mastering of fundamental mathematical concepts when a graphing utility is used.

- **Verification and illustration**. To aid in mastering fundamental mathematical concepts, graphical interpretation should be accompanied by algebraic verification (orally and/or in writing) and algebraic results should be illustrated graphically. Students should be encouraged to 'speak mathematics' and explain the visual images on the screen. The task of the facilitator in this regard is to listen and prompt students to (re-)formulate mathematically correctly. Having formulated the concept verbally, they then need to write it down in mathematical symbols. This coherence between exploration and verification promotes the utilisation of linear as well as global hemisphere cognitive activities and promotes deeper understanding of the concepts involved.

- The **left-to-right principle**. Graphical exploration and interpretation should be done starting from the left side of the screen (following the curve displayed on the screen) and working towards the right side. This is important, as analytical mathematical theorems that reflect on two-dimensional functions postulate concepts for increasing values of x. There is one exception to this principle, namely, when limits from the right, $\lim_{x \to a^+} f(x)$, are explored.

It should be pointed out that the researcher invariably experienced that learners do not know where to begin (the left side or right side) when they have to interpret a graphical image.

- **The principle of non-assumption**. Learners need to be taught how to explore graphs and make meaningful interpretations. Facilitators of learning should never assume that learners observe and deduce from graphical images what teachers expect students to observe and deduce. Fuchsteiner (1997:16) remarks that *we must start [our teaching] where students are rather than where we wish they were*. It is thus the task of the facilitator to ensure that the learner accomplishes what he/she is intended to master.

- The **tool principle**. It should be stressed that the facilitator should view technology (such as a graphing utility) as a tool to aid learning and enhance teaching. Technology should neither intimidate a learner nor dominate instruction.

- The **assessment, grading and feedback of answer sheets** are done in order to ascertain that students write down mathematics correctly. The focus is thus not on numerically correct answers but on the way in which they are written down. The lecturer (researcher) regards the continual assessment, grading and feedback of the answer sheets as of primary importance in the learning facilitation strategy proposed in this thesis.

5.6.2 Instructional media

The instructional media[85] used for the facilitation of the mathematics in the POSC include graphing software and paper based instructional material. The arrangement of the instructional media in the implementation of the proposed learning facilitation strategy is illustrated in Figure 5-9 on page 218.

During 2000-2002 the package *Fundamentals of 2-D Function Graphing – a practical workbook for precalculus and introductory calculus* (Greybe, Steyn & Carr, 1998) was used.[86] This package consists of a workbook, accompanying answer sheets and graphing software, namely, *Master Grapher for Windows* (Carr & Steyn, 1998).

The software *Master Grapher for Windows* is a tool that generates the graphs of two dimensional functions and comprises a graphing utility, three computer based interactive tutorials and an online help.

- **The graphing utility**

The graphing utility represents a two-dimensional coordinate system and the main user interface is window where graphs are drawn and from which the other options of the software, needed for exploration, can be accessed. The main window is displayed in Figure 5-7. The equations of the functions to be drawn are entered in an equation editor which is displayed in Figure 5-8.

The software was designed to promote self exploration by a learner. The following technical features of the software support the exploration activities (Steyn, 1998):

[85] The term "medium" refers to *the means by which something is communicated* (Thompson, 1995:847).
[86] The use of this package is a *sine qua non* in the learning facilitation strategy proposed in this thesis. Continual revision of the workbook remains an ongoing priority.

- The skill to use the software is acquired within 1-2 hours (even for inexperienced computer users).[87]
- Entering of functions is easy.
- Up to five functions can be displayed simultaneously.
- Functions are colour coded to aid in distinguishing displayed functions from each other.
- Entered functions can easily be displayed or not-displayed by clicking on the coloured box in the 'function display window' (see Figure 5-7).
- A cross-hair cursor as well as the 'cursor position block' indicate the current position on the two-dimensional plane (see Figure 5-7).
- Exploratory activities, e.g. following a curve 'physically', is done with a mouse.
- A right mouse click gives the measured position of the cursor and this position is indicated with blue dotted lines on the 'graph window' and displayed in the 'measured position' block.
- A 'tick interval' block indicates the scaling of the axes.
- The dimensions of the graph window[88] is easily changed by clicking on the 'axis limit' blocks or accessing the menu option 'Scaling of the axes' under the 'Options' menu. The default dimensions is [Xmin, Xmax] x [Ymin, Ymax] = [-10, 10] x [-10, 10] and is written in this notation.
- Toggling between two consecutive graph windows is easy. This option is accessed through the menu item 'View' (see Figure 5-7).
- Vertical and/or horizontal lines can be set (fixed) at required values for determining *x*- and *y*-values, respectively.
- Moving vertical and/or horizontal lines can be activated and used for exploration. This exploration is especially conducive for active and intuitive exploration of images.
- Repeated zooming is possible and is done by accessing the 'zoom' feature under the 'View' menu and using the mouse.
- The larger viewing area and better resolution of a computer screen (in comparison with that of a graphing calculator) is conducive to authentic graphical exploration.

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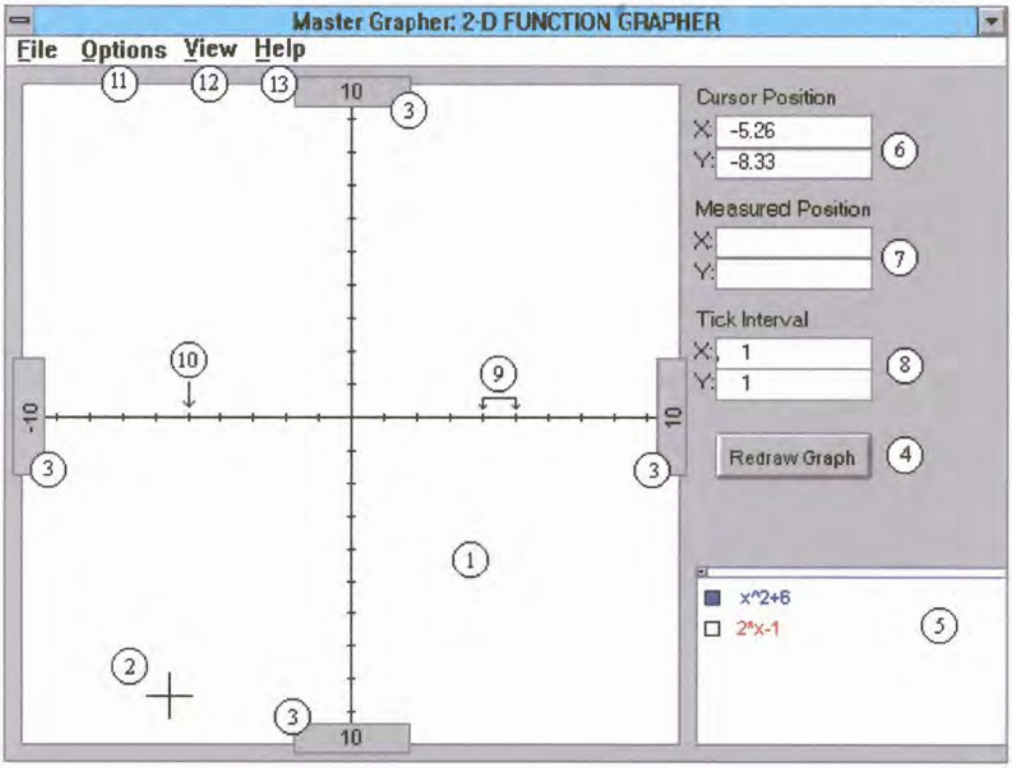
[87] Refer to Table 5-8 for detail on the entry level of computer experience of the POSC students.
[88] In some graphing utilities and textbooks the phrase "viewing rectangle" is used to indicate the 'window' in which the 'graph' is displayed.

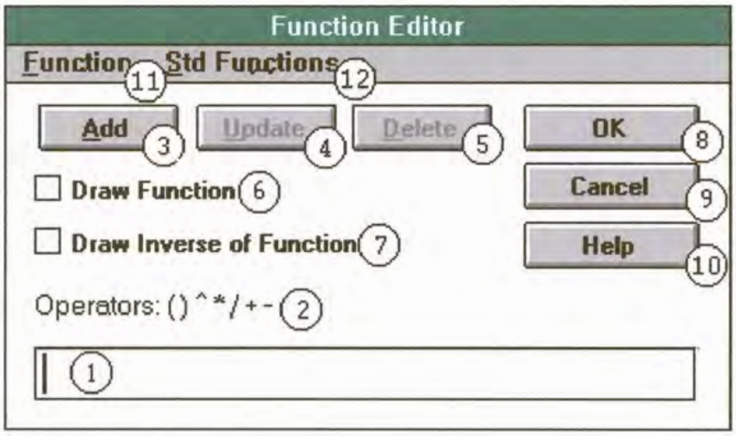
Figure 5-7 The main window of the software *Master Grapher for Windows*



- Functions are plotted in the **Graph Window** (also referred to as a **Viewing Rectangle)**
- **Cross-hair cursor** shows the current *x* and *y* coordinates. See also ⑥
- **Axis limit blocks** show the current [Xmin, Xmax] x [Ymin, Ymax]
- **Redraws** the graph(s) of the selected function(s)
- **Function Display Window** shows the current functions. See **Function Editor** on the next page.
- **Cursor Position** shows the *x* and *y* coordinates of the cross-hair cursor ②
- **Measured Position** fixes the current *x* and *y* coordinates of the cursor with dotted horizontal and vertical lines, and is set by clicking with the right button.
- **Tick Interval** shows the distance between ticks on the *X*- and *Y*-axes. Scaling on the two axes may differ.
- A tick interval is the physical distance between the ticks on the axes. See also ⑧
- **Tick marks**, together with **Cursor Position** ⑥, the **Tick Interval** ⑧ and the **Axis Limit Blocks** ③, replace a grid.
- Menu item: **Options** for options concerning the Graph Window, such as functions and scaling the axes.
- Menu item: **View** for options in exploring the behaviour of graphs.
- Menu item: **Help** gives information on using *Master Grapher for Windows* as well as information on some mathematical topics.

Adapted from Greybe, Steyn & Carr (1998:3)

Figure 5-8 The function editor of the software *Master Grapher for Windows*



- Use the **Function Typing Box** to enter functions.
- These are the allowed operators in *Master Grapher for Windows*.
- Button to **add** the function in the Function Typing Box ① to the list of saved functions.
- Button to **replace** a function with the one in the Function Typing Box ①
- Button to **delete** the function in the Function Typing Box ①
- Click on the **Draw Function** option to have *Master Grapher for Windows* plot the function in the Function Typing Box ① when the Function Editor is closed.
- **Draw Inverse of** (the) **Function** in the Function Typing Box ①. This option is only active if **Draw Function** ⑥ is active.
- The **OK** button is used to accept all changes made to functions in the Function Editor.
  The list of functions can only be modified through the **Add**, **Update** and **Delete** buttons.
- The **Cancel** button is used to discard any changes made.
- The **Help** button is used to access Help on the Function editor.
- Clicking on this menu option gives a list of the current functions. A function can be selected into the Function Typing Box ① by clicking on it.
- A list of standard functions available in *Master Grapher for Windows*. These can be selected into the Function Typing Box ① by clicking on them.

Adapted from Greybe *et al.* (1998:5)

- **The interactive tutorials**

The first tutorial, *The Cartesian Coordinate Plane*, covers the basics of a coordinate reference system, the fundamentals of the two-dimensional plane and introduces the student to the coordinate system of the graphing utility, *Master Grapher for Windows.*

The second tutorial, *Fundamentals of 2-D Graphing*, is aimed at giving the students the basic knowledge for using a graphing utility when exploring two-dimensional functions.

The third interactive computer tutorial, *Graphing Trigonometric Functions,* includes radian measure and the fundamentals of graphing the trigonometric functions sine, cosine and tangent.

- **The online help**

The online help explains the features and use of the software and includes extensive help on topics of fundamental mathematics that is related to two-dimensional function graphing.

- **The workbook**

The workbook is made up of worksheets, each focusing on a different topic. In each worksheet selected examples are explored through a sequence of activities. The results of these explorations are written up on answer sheets which are designed in a special format to correspond with the worksheets. The uniform structure of the answer sheets also eases the marking and grading of the learners' answer sheets. An example of a worksheet is attached in Appendix B.

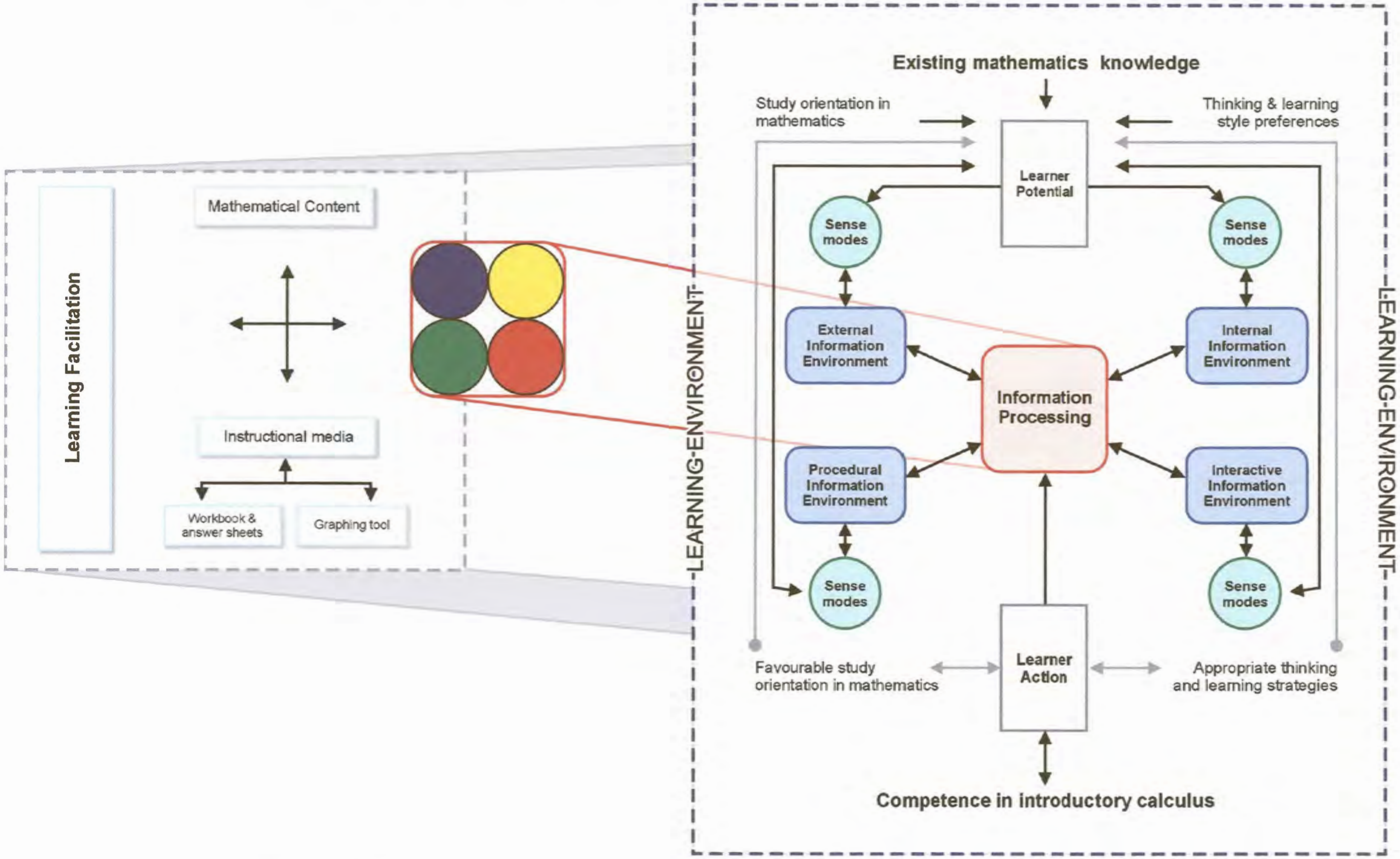
In Table 5-10 a summary of the main characteristics of the instructional package is given.

Table 5-10 A summary of the instructional media

Medium	Comprises of	Characteristics	Special features
Computer software	Graphing utility	Exploration tool Meaningful image	Large screen Ease of use Moving lines Fixed lines Easy zoom
	Tutorials	Fundamentals of a 2-D coordinate system Fundamentals of graphical exploration Trigonometric functions	Interactive Computer based Self-paced
	Online help	Help for user working alone	
Workbook	Worksheets	Structured explorations Read, understand and write mathematics	Practical workbook, not a textbook Clear lesson objectives Margin notes
	Appendices: Interpreting graphs	Awareness of limitations of technology	
Answer sheets	Formatted to accompany a specific worksheet	Ease of use for students Uniform format for marking	Fill-in format Exercises in writing mathematics Pen & paper graphs

Adapted from Steyn (1998:163)

Figure 5-9 Implementation of the proposed learning facilitation strategy



Proposed and compiled by the author of this thesis

5.6.3 Learning facilitation of mathematics

The learning facilitation of mathematics in the POSC can be described as composite and aimed at developing the mathematics potential of the learner. This implies that all the components of learning facilitation strategy illustrated in Figure 5-9 should ideally be addressed and functionally optimised.

Due to the very nature of the concept "support"[89] within the context of this study, the proposed learning facilitation strategy for mathematics does not focus solely on mathematical content but also includes the development of skills for learning mathematics. It should be stressed that the learners are not merely trained to use the skills as recipes for applications. The development of skills for learning (mathematics) is treated as an integral part of both the facilitation strategy for mathematics and of the philosophy underpinning all the activities of the POSC namely, the development of the mathematics potential of a learner following an integrated whole brain approach.

As the instructional strategy for mathematics learning facilitation strongly advocates a whole brain approach to learning and teaching, students need to be made aware of the concept of whole brain utilisation. Students also need to gain insight into their own thinking and learning style preferences and should realise that they need to develop skills to utilise their less preferred thinking and learning modes.

In addition to the development of the mentioned skills that are integrated in the strategy, mind mapping is introduced as a specific and recommended learning and study tool for mathematics. The motivation to include mind mapping is based on the premise that in the construction of a mind map the activity presupposes utilisation of diverse thinking (learning) preferences according to the four quadrant whole brain model. The researcher highly values mind mapping as a study tool as this gives students practice in developing gestalt (global) thinking activities. Although mind mapping is foremost a global approach, it also incorporates linear thinking activities that contribute to whole brain uitlisation.

Mind mapping seemingly has a positive effect on students' learning of mathematics (Steyn & De Boer, 1998). Melton *et al.* (2001:27) also report that results from an experiment with

[89] See Chapter 1 section 1.2.6 for an explanation of the term "support" within the context of this thesis.

mind maps in a college algebra class *support the hypothesis that the use of mind maps by these students can improve their mathematical skills.*

5.7 Implementing and monitoring the research instruments

The researcher is of the opinion that a relationship of trust and understanding should exist between the lecturer (researcher) and the students (participants) before research instruments (such as questionnaires) are administered in any research done in a classroom. Furthermore, freshmen students need time to get used to their new environment and some time has to elapse between all the forms that students have to complete during registration at the university and the completion of research questionnaires. Therefore the first questionnaire for the purposes of this study was completed after five academic weeks in 2000 and 2001. It was done in the week following on the first test week of the School of Engineering.

In all instances where questionnaires were completed during the 2000-2002 studies, students were informed of the activity and the purpose of the instrument was explained. Students were also informed regarding the possible benefits of the instrument for themselves and they were assured that all data is treated anonymously. Furthermore, it was explicitly stated that although completing a questionnaire was part of the POSC activities, it was not compulsory.

The following sections describe the implementation of each of the instruments that were used during this research as well as the researcher's observations regarding the implementation of the instruments.

5.7.1 The Study Orientation Questionnaire in Mathematics (SOM)

5.7.1.1 Implementation of the SOM

The original SOM (Maree, 1996) and accompanying answer sheet were used as pre-intervention instrument during both the 2000 and 2001 research activities.

The lecturer (researcher) used the administering of the instrument as an opportunity to stress the importance of physical wellness and that a healthy diet and ample water intake

(Hannaford, 1995; Dennison *et al.*, 1989) are important while studying. The questionnaire was administered late morning and the researcher assumed that the students could be hungry and or tired. Therefore they each received a snack before doing the questionnaire. This hopefully conveyed the message of basic physiological needs to be met for sustained academic (brain) activity.

The lecturer (researcher) went through the instructions of the original SOM manual with the students, highlighting the meaning of the five categories used for answering the questions of the SOM. The researcher stressed the fact that the questionnaire was not a test and the students were told to ask whenever they encountered a word or question that they do not understand. Students were allowed to leave when they were finished.

The answers were processed and scored by the researcher according to the prescribed instructions and format. The SOM profile of each student was drawn.

In 2000 the lecturer (researcher) gave the feedback on the SOM to the class as a group. Due to the scheduling of the POSC activities, this was done three weeks after the instrument was administered. Every student got his/her own answer sheet with the SOM profile already drawn. An example of a SOM profile[90] was used to explain the interpretation of profile and the meaning of the six fields of the SOM. The lecturer (researcher) also encouraged the students to consult with her regarding any further queries they may have regarding their SOM profiles.

In 2001 the lecturer (researcher) gave the feedback on the SOM to students individually during 10-15 minute interviews that were conducted in the last two weeks of classes prior to the exam period. Each student's profile was explained and discussed with him/her. This feedback on the SOM was done together with feedback on the other instruments (the LAS and ILS).[91]

[90] See Chapter 4 Figure 4-5 for an example of a SOM profile.
[91] See sections 5.7.4.1 and 5.7.5.1.

5.7.1.2 Monitoring the implementation of the SOM

The time scheduling for doing the SOM was appropriate both during 2000 and 2001. No problems were encountered in the administering of the SOM and the students cooperated well. It took the students approximately 20-30 minutes to complete the questionnaire. In 2000 two students did not participate in the activity but in 2001 all the students attended the session. During 2000 three of the students were unfamiliar with the term "perspire" used in question 56 of the SOM. In 2001 the researcher pointed out that the term "perspire" means "sweat".[92]

The answer sheets were checked to ensure that only one answer per question was marked, that the maximum number of unanswered questions was within the range allowed and that no gross deviations occurred in the way the answers were given, for example all answers marked in the same position on the answer sheet. During 2001 one answer sheet could not be scored due to anomalies and the scoring of another required special attention. Both these cases were followed up during the individual feedback sessions.

The lecturer (researcher) experienced the group feedback during 2000 as unsatisfactory for the following reasons. Although students seemingly followed the explanation of how to interpret the SOM profile and what the fields of the SOM meant, it cannot be deduced that the students benefited from the activity. Furthermore, only four students followed up the invitation for further consultation. Of these, two students had an average SOM profile of above 90, one's average was 80 and the other 66. These students were not necessarily those in need of consultation and those who could have benefitted from consultation did not follow up.

As the focus of the learning facilitation strategy in the POSC strongly proposes a developmental approach, an educational research intervention such as the SOM should be utilised to aid learner support and development and not merely as another activity. Based on this experience, the feedback on the SOM during 2001 was done individually. During these individual sessions the interviewer (lecturer/researcher) made sure that the student was at ease. The student was asked whether it was in order if the interviewer made notes during the conversation and none of the students were disturbed by this request.

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[92] In the SOMT version, the term "sweat" was added in brackets.

The individual feedback in 2001 comprised feedback on a student's SOM profile as well as feedback on the LAS and the ILS. Students received their SOM answer sheet with the SOM profile. A copy of this document is given in Appendix G.

The sessions were well-timed with regard to the students' own experience of university study. It so happened (without deliberately planning before hand) that the interviews were conducted after the students had done a mathematics worksheet[93] in which aspects related to problem solving behaviour and information processing (two specific fields addressed in the SOM) occurred. This posed the opportunity to ask the students how they had coped with the worksheet and this information was linked to the two fields (Problem solving behaviour and Information processing). Furthermore, the researcher (lecturer) found it meaningful to give feedback incorporating all the available information gained through the applied questionnaires. It is noteworthy that all the learners could identify with their SOM profile. These interviews also gave the students an opportunity to verbalise some aspects of their mathematics background and learning that seemingly concerned them. Overall, the lecturer (researcher) got the impression that the students appreciated the opportunity for this type of one-on-one discussion.

5.7.2 The Study Orientation Questionnaire in Mathematics Tertiary (SOMT)

In the initial planning of the 2000 research study the administering of the original SOM as a post intervention instrument was not precisely scheduled as the researcher felt that certain questions in the original SOM are too focused on mathematics within a school environment to be used with students after they had already completed a semester of tertiary study. Following on this reasoning, the researcher engaged in a series of adaptations of the original SOM that resulted in a version for use with tertiary students. The details of these adaptations are adressed in Chapter 4. The first version of the adapted questionnaire, the Study Orientation Questionnaire in Mathematics Tertiary (SOMT-1) was administered to both the 2000 and 2001 POSC students in the second semester of 2001.

[93] See Appendix B.

5.7.2.1 Implementing the SOMT in 2001

The students were again made aware of the fact that the questionnaire was not a test and that they should interpret it with regard to the standard mathematics course (and not the mathematics component of the POSC).

The POSC students of 2000 did the SOMT-1 at the beginning of the second semester, in June 2001. The questionnaire was e-mailed as an attachment (in a MS Word document format) and students had to complete it by typing an X in the appropriate space. They completed it in their own time and mailed it (as an attachment) back to the researcher. The students reported that it took about 20 minutes to complete the questionnaire. No formal feedback was given to these students.

During 2001 the SOMT was also e-mailed as an attachment to the POSC students of 2001 and they completed it early in September in a scheduled POSC period. Again it took about 20 minutes to complete. Feedback on the SOMT was again given to the students individually by way of a handout showing both the SOM and the SOMT profiles of the student and a short consultation. An example of the handout used during the feedback session is given in Appendix G.

5.7.2.2 Monitoring the implementation of the SOMT

As the POSC students of 2000 did the SOMT when they were no longer enrolled for the POSC, some logistics challenges arose. The SOMT questionnaires were mailed only to the 31 POSC students of 2000 who completed the SOM in 2000. Of these 27 replied. Efforts to contact the other four students were unsuccessful. For logistical reasons no feedback was given to the students which is an unsatisfactory outcome for an educational research activity.

During 2001 the administering and feedback of the SOMT were timed appropriately. Feedback was given individually in the last two weeks of the second semester. Students were seemingly interested in comparing their SOM and SOMT profiles. During the interviews they were encouraged to air any concerns they had. Again it seemed that the students appreciated the opportunity of one-on-one contact and the personal feedback. In this way the researcher felt that these final interviews wrapped up participant observation regarding this group of students.

5.7.3 The Herrmann Brain Dominance Instrument (HBDI)

5.7.3.1 Implementing the HBDI in 2000

Research activities concerning the HBDI in 2000 involved the POSC students as well as the freshman civil engineering students of 2000.

The civil engineering students did the HBDI during March 2000 and the POSC students at the end of April. Both groups of students did the HBDI online in a computer laboratory. The data was processed and electronically scored through Herrmann International in the USA.[94]

Feedback on the interpretation of a HBD profile as well as information regarding Herrmann's four quadrant whole brain concept were given to both groups of students separately. The researcher gave the feedback on the HBDI to the civil engineering students at the beginning of the second term (in April) and to the POSC students at the start of the second semester (in mid July). A copy of a thinking preference profile according to HBDI is included in Appendix D.

For the POSC students and the civil engineering students the individual results of the HBDI were used to organise them into groups of four. The aim was that each group should be balanced in terms of the represented quadrants of the Herrmann whole brain model. Such a balance ideally should result that the average profile of the group members represents a profile with evenly balanced preferences in all four quadrants.

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[94] See Chapter 4, section 4.6.6.

5.7.3.2 Monitoring the implementation of the HBDI in 2000

The implementation of the HBDI is a timely process. It is dependent on the availability of computer facilities to do the questionnaire or the questionnaire has to be done as a pen and paper version and the data then entered manually into the electronic system. Processing of the data is, amongst other things, dependent on the electronic connection with the scoring centre in the USA. During 2000 numerous technical problems were experienced in this regard. This eventually led to delay in the feedback to the POSC students.

5.7.4 The Lumsdaine and Lumsdaine learning activity survey (LAS)

5.7.4.1 Implementing the LAS

The research activities concerning the LAS in 2000 involved the POSC students as well as the freshmen civil engineering students of 2000. Both groups of students did the LAS before they were given information on the four-quadrant whole brain concept and before feedback on their results of the HBDI were given. The civil engineering students did the LAS towards the end of the first term (in April) and the POSC students did it at the beginning of the second semester (in mid July). As the LAS is an easy to do, self-scoring instrument, the students completed the LAS as homework and compiled their preference scores. An example of the LAS is attached in Appendix E.

During 2000 feedback on the LAS was given to the POSC students and the civil engineering student groups separately. The researcher gave feedback to the POSC students simultaneously with the feedback on the HBDI. For the civil engineering students the feedback on the LAS was given by their lecturer in the module Practical Orientation.[95]

During 2001 the research activities pertaining to the LAS reported in this thesis only included the POSC students. They had to complete the LAS as homework and submit it to the lecturer (researcher). In the following week the students were asked also to complete the ILS.[96] The lecturer (researcher) made a copy of each student's LAS survey and the ILS for use in follow up consultations with the students. The administering of these instruments was done towards the end of April between the two test weeks in the School of

[95] This module was presented to first year civil engineering students and was aimed at preparing them to function as professionals combining academic and professional proficiency, personal, interpersonal and communication skills. In 2001 the module was replaced by another, Innovation, that has similar focuses.

[96] See section 5.7.4.2.

Engineering. Feedback on these questionnaires was given to the class as a whole and the distribution of preferences for the group was indicated. Feedback was also given to the students individually during the mentioned interviews.

The researcher (lecturer) compiled a feedback sheet[97] for each student that included a photo[98] of the student, a section where the student had to write the results of the ILS and a section where the results of the LAS had to be written. The original copies of the students' completed LAS and the ILS were also handed back. The students transferred the data to his/her feedback sheet where after the researcher (lecturer) discussed the interpretation of the data.

This discussion started with information pertaining to the physical organisation of the human brain and students were introduced to the Herrmann four-quadrant whole brain concept. The information on whole brain utilisation and the different modes of learning according the Lumsdaine and Lumsdaine model[99] were discussed. Then the data for the group as a whole according to the LAS survey and the ILS was discussed. The distribution of learning preferences and learning styles for the class were discussed. Learners' expectations and possible constraints as proposed by the Herrmann model (and as indicated by the LAS) were pointed out using a handout containing the information as in Figure 5-10.

These activities took approximately an hour. Then the students were given a short (10 minute) break. To link the principle of whole brain utilisation to learning and studying the following hour was devoted to information on mind mapping as a study tool.

In addition to the feedback and information session to the class as a whole, feedback was also given to students individually towards the end of the first semester (in May). The lecturer (researcher) compiled a feedback sheet[100] similar to the one mentioned above for use in these interviews. The aim with these interviews was to deliberately make one-to-one contact with all the students; give them feedback on the SOM and integrate all the information presented by the instruments used so that the data made sense to the students.

[97] See Appendix G for an example of the feedback sheet.
[98] The lecturer (researcher) compiles a photo class list at the beginning of the year. These are stored electronically and used as needed.
[99] See Chapter 3 section 2.5.2
[100] See Appendix G for an example.

The students also had the opportunity to communicate with the lecturer on any aspect pertaining to their tertiary environment and experiences to date. Once again the students seemingly appreciated the opportunity of one-to-one communication with the lecturer (researcher).

Figure 5-10 Learners' expectations according to the Herrmann model

Herrmann International (1999a)

5.7.4.2 Monitoring the implementation of the LAS in 2000 and 2001

The LAS survey is easy to administer and to score and students can easily do it on their own. To make the interpretation of LAS meaningful, information regarding the four quadrant whole brain model and the principle of whole brain uitilisation should be given.

5.7.5 The Felder Soloman Index of Learning Styles (ILS)

5.7.5.1 Implementing the ILS in 2001

The ILS was used in the 2001 study only. The students completed the pen and paper version of the ILS as homework and had to submit it the following day. The researcher then checked the students' scoring of the questionnaire and made a copy of each. These were kept as records to be used for feedback to the students as well as for the research reported in this thesis.

Each student's copy of his/her ILS was handed back during a follow up class information session and feedback was done as discussed in section 5.7.4.1 above. In addition to the mentioned feedback each student also got a copy of the explanation sheet (Soloman & Felder, 2001) accompanying the ILS.[101]

5.7.5.2 Monitoring the implementation of the ILS in 2001

The ILS is easy to administer as the questions are well formulated, easily understood and the students can score the ILS themselves. The ILS is also easy to interpret following the reasoning in the accompanying explanation sheet.

The researcher included the ILS instrument in the present study to determine its usefulness in enhancing students' awareness of their learning styles and to create an further awareness that they need to be able to function in all the categories of the ILS.

5.8 Assessing the 2000 and 2001 research

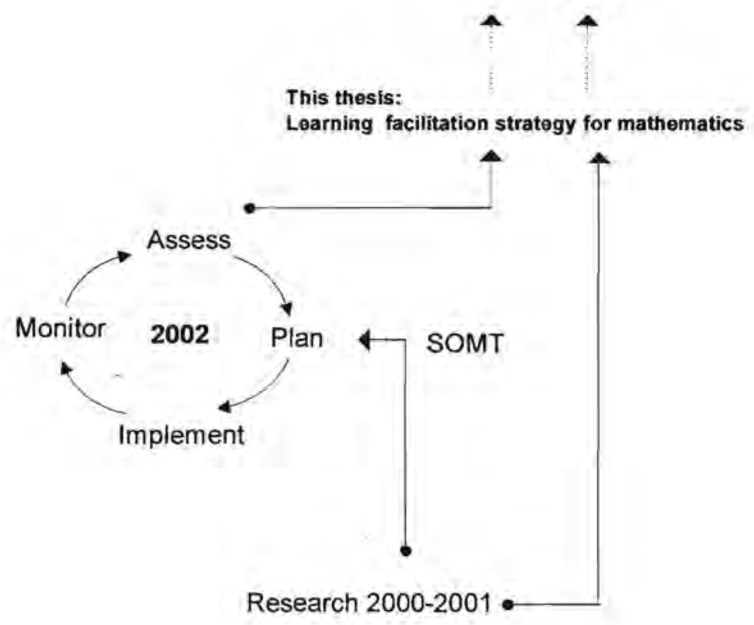
The assessment of the studies comprises the analysis of the research data and the quantitative and qualitative interpretation thereof. The research results are presented in Chapter 6 and discussed in Chapter 7 and the assessment of the 2000 and 2001 studies are included in these discussions.

[101] A copy of the explanation sheet is included in Appendix F.

5.9 The 2002 research

The main aim during the 2002 research was to further refine the adapted SOMT-1. It should, however, be pointed out that the activity of implementing the SOMT as a pre- and post-intervention instrument was totally integrated into the 2002 course activities. Furthermore, the learning facilitation strategy for mathematics, proposed in this thesis, was again implemented in the POSC. For the purpose of this thesis the action research cycle of 2002 concerning the SOMT is briefly discussed in the following sections. The diagram in Figure 5-11 illustrates the action research cycle of 2002.

Figure 5-11 Action research cycle 2002



Compiled by the author of this thesis

5.9.1 Participants of 2002

The POSC class of 2002 comprised 52 students in the first semester of whom 12 are female. During the second semester there were 49 students including the 12 female students. All of the students are black and an African language is the mother tongue of all the students.

At time of writing the average M-score of this group was not available. Records since 1994 indicate that the average M-score of the POSC students is approximately 7 points lower that of the students on the 4YSP and 2-3 points lower than that of the other 5YSP students (Du Plessis, 2002).

Of the 52 students, 28 had had no previous exposure to computers. Nineteen students indicated that they had had previous experience with computers that was limited to introductory usage skills, some word processing and spread-sheet use.[102] Five students indicated that they had computers at home of which two have Internet access. Again none of the students had used a computer for mathematics before.

The SOMT-2 was done by 50 students during March 2002 and 47 students completed the SOMT-3 in August 2002 during the second semester. All 52 students completed the ILS during the first semester.

The identifying attributes of the POSC participants in 2002 are summarised in Table 5-11 on the following page.

[102] Although the students with "limited" computer knowledge indicated that they had skills with regard to word processing and spreadsheet use, the researcher again found during course activities in the second semester of 2002 that none of these students were proficient users of any application program.

Table 5-11 Attributes of the POSC participants of 2002

		Number of students 2002
Male		40
Female		12
Total		52
Mother tongue:		
	African language	52
Language of high school instruction in mathematics:		
		English
Average M-score:		
		Not available
Computer experience prior POSC enrollment:		
	No experience	28
	Limited experience	19
	Experience	5
	Used for mathematics	0
Participation in the:		
	SOMT-2 March 2002	50
	SOMT-3 August 2002	47
	ILS	52

5.9.2 The research activities of 2002

The 2002 research activity addressed the first three research questions stated in Chapter 1 with a particular focus on the first two research questions.[103]

[103] See Chapter 1 section 1.4 and section 5.5.2 of this chapter for detail on the research questions.

5.9.2.1 Planning the research activities of 2002

Similarly as in the research conducted during 2000 and 2001, the scheduling of the action research activities and the course activities during 2002 had to be done in such a way that the administering of the questionnaires for the purposes of the research had to be incorporated into the course activities so that they would be appropriate for the course content and had to be given at a time when students could realise the need thereof and could benefit from the resulting information.

5.9.2.2 Implementing and monitoring the research activities of 2002

Following the same schedule as in 2000 and 2001, the SOMT as a pre-intervention instrument was administered just after the first test week of the School of Engineering in the middle of March 2002. The SOMT as a post-intervention instrument was administered at the beginning of the second semester in August 2002.

Feedback on the SOMT during March was given to the group as a whole and as follows. The fields of the SOMT were explained and each student received a feedback form[104] on which he/she had to draw his/her study orientation profile. Feedback on the SOMT during August was conducted slightly differently and in the following way.

During the second semester a major focus of the POSC is on communication skills and in particular on scientific writing skills. This focus on developing writing skills as well as some analytical skills was incorporated into the follow up on the SOMT in August. Each student received a handout containing his/her SOMT scores of March and August as well as a writing assignment.[105] Again the fields of the SOMT were discussed in class and the students had to draw their two profiles (in class) on the same grid. For homework each student then had to analyse his/her profiles and give possible explanations for improvement/deterioration in their individual study orientation. They also had to reflect on the extent of correctness that the profile(s) give of their study orientation. They were given a week to compile and type the analysis of their study orientation profiles. The assignments were assessed and graded with regard to language use.

[104] Examples of the 2002 feedback forms for March and August are included in Appendix G.
[105] An example of the assignment is included in Appendix G.

5.9.2.3 Assessing the research activities of 2002

For the purpose of the research reported in this study, the written reflection of the students on their own profiles not only encouraged them to really think about their study orientation but also served as a source of information aiding the researcher in the interpretation of the data pertaining to study orientation. Only two students did not submit this written assignment. The results of the SOMT profiles of the 2002 study and the mentioned feedback of the students are given in Chapter 6 and discussed in Chapter 7.

5.10 Summary

In Chapter 5 the research activities during 2000 and 2001 that form the main focus of the present study reported in this thesis are discussed. The research activities are described within the context of the Professional Orientation Support Course of the Five Year Study Programme in the School of Engineering. The action research phases pertaining to the planning, implementation and monitoring of the research are detailed.

The planning phase concerned identifying the research participants, detailing the specific research activities and listing the scheduled activities of the POSC.

The implementation phase concerned that of the learning facilitation strategy and the research instruments. The implementation of the learning facilitation strategy for mathematics that is proposed in Chapter 3 is discussed in Chapter 5, highlighting the tasks of the facilitator, the instructional media used and how learning is facilitated. The implementation and monitoring of the research instruments are discussed including the Study Orientation Questionnaire in Mathematics and the Study Orientation Questionnaire in Mathematics Tertiary, the Herrmann Brain Dominance Instrument, the Learning Activity Survey and the Felder Solomon Index of Learning Styles.

The research study of 2002 that addressed further adaptations to the Study Orientation Questionnaire in Mathematics Tertiary is also discussed giving details on the planning, implementation and monitoring of the research activities.

In Table 5-12 a summary is given of the research interventions during 2000-2002, the research instruments implemented as well as the relevant statistical procedures used for processing the research results. In Chapter 4 details on the research instruments are given. In Chapter 5 the research interventions are detailed. The statistics of the results are presented and analysed in Chapter 6 and in Chapter 7 the results are further interpreted and discussed.

Table 5-12 Research interventions, research instruments and statistical procedures

	Pre-intervention	Intervention	Post-intervention
	Learning facilitation strategy		
Instruments	SOM SOMT-2	HBDI LAS ILS	SOMT-1 SOMT-3
Statistical procedures	Item analysis Cronbach alpha Regression analysis	Kruskal-Wallis test Pearson correlation	Item analysis Cronbach alpha Wilcoxon test Pearson correlation ANOVA