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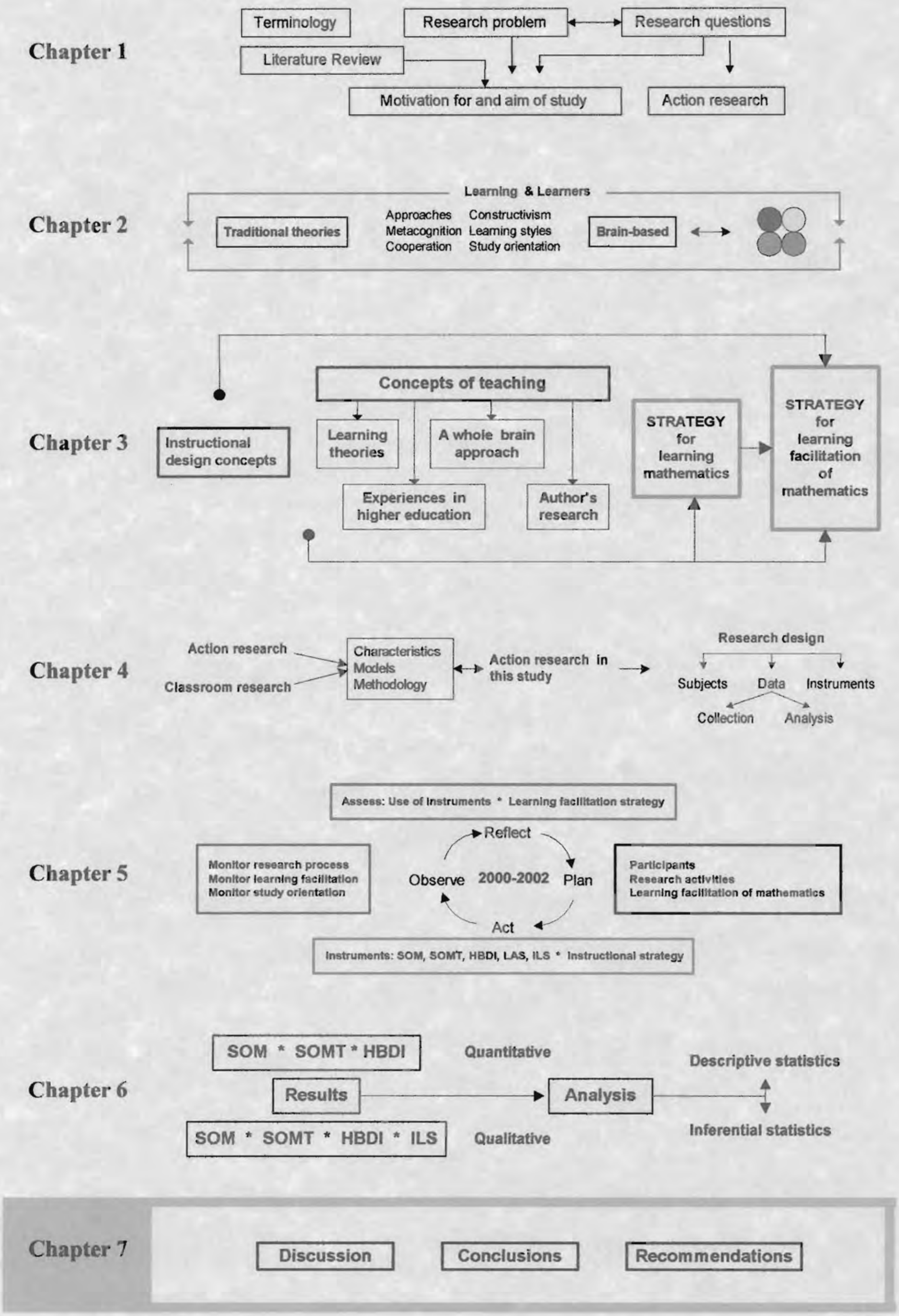

Discussion, conclusions and recommendations

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Chapter 7

Discussion, conclusions and recommendations

7. Introduction

The primary objectives of the research reported in this thesis were 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.

In Chapter 2 aspects of learning relevant for the proposed learning facilitation strategy were identified. In Chapter 3 the learning facilitation strategy was defined. The research approach followed in this study was discussed in Chapter 4. In Chapter 5 the implementation of the strategy in the research studies during 2000-2002 was detailed. In Chapter 6 results pertaining to the effects of the strategy were presented and qualitatively and quantitatively analysed. In this chapter the focus is on determining whether the aims of the research has been met and the research questions answered.

In the following sections the research results, with reference to the effects of the implementation of the learning facilitation strategy on study orientation in mathematics and performance in mathematics, are discussed; insights gained during the study regarding the thinking style preferences of the students are then presented and the main aspects of the proposed learning facilitation strategy are highlighted. The chapter concludes by identifying possible limitations of the study, noting areas for further research and concludes with remarks on the use of the proposed learning facilitation strategy.

7.1 Discussion

In Table 7-1 the research questions and main research finding of the present study are summarised and aspects thereof are further highlighted in the discussion that follows.

Table 7-1 Research questions and main research findings

Research question	Research findings
1 What is the study orientation towards mathematics of the students enrolled for the POSC?	A specific trend regarding the POSC students' study orientation toward mathematics is noticeable that displays the following characteristics: • The POSC students seem to have a neutral to favourable study orientation towards mathematics. • Their mathematics confidence and study environment might influence their study orientation negatively. • The POSC students seem to have a fairly good study attitude toward mathematics.
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?	• The learning facilitation strategy followed in the POSC seemingly has a positive effect on the students' study orientation in mathematics and there is an improvement in the students' study orientation towards mathematics. • This improvement is noticeable for the 2000, 2001 and 2002 students. • Students' study attitude towards mathematics is seemingly vulnerable once they have left the environment of the POSC. In this regard it may be necessary to place stronger emphasis on the students' awareness and understanding of their own study orientation profile 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?	• The POSC students outperformed the other 5YSP students. • The grades of the POSC students compare favourably with that of the 4YSP students.
4 What are the thinking style preferences of first year engineering students enrolled for the POSC?	• The individual HBD profiles of the POSC students represent diverse thinking preferences in all four quadrants of the Herrmann model. • The average HBD profile of the POSC students displays a generic whole brain profile indicating the group represents thinking preferences distributed across all four quadrants of the Herrmann whole brain model. • Qualitative analysis of the ILS point to the following trends for both the 2001 and 2002 groups: A greater preference for visual than for verbal; A greater preference for sensing than intuitive; Almost equal preferences for sequential and global; Almost equal preferences for reflective and active but not the same distribution for the 2001 and 2002 groups.

7.1.1 Study orientation in mathematics

The study orientation profiles of the learners were interpreted in a diagnostic and evaluative manner. The facilitator gained insight into the study orientation of individual learners as well as into that of each of the POSC groups. The learners themselves became aware of their own study orientation. Comparing the group profiles at course beginning and at course end gave an indication of change in learners' study orientation.

In Figure 7-1, Figure 7-2 and Figure 7-3 on the following pages, the study orientation profiles in mathematics for the 2000, 2001 and 2002 POSC groups are given. These profiles were compiled for the different groups using the average score in each of the fields of the questionnaire. For the purpose of this discussion they will be referred to as "group profiles". In each case the profile indicated with a dotted line refers to the results of questionnaire done at the beginning of the POSC and the profile indicated with a solid line refers to the results of the questionnaire done after the POSC. Profile scores[118] of 40% and below indicate an unfavourable study orientation in that aspect; scores between 40% and 69% indicate a neutral study orientation and scores of 70% or above indicate a favourable study orientation. According to Maree *et al.* (1997:15) a neutral study orientation *can contribute to a positive or negative study orientation or aspect of it.*

It is noticeable that for all three the groups the scores in the fields Mathematics confidence and Study environment are the lowest both at course beginning and at course end. However, the group profiles at course end show a higher score in each of these fields. The results in Chapter 6 indicated that for all three the POSC groups the improvement in mathematics confidence was statistically significant.

Furthermore, none of the profiles is located in the unfavourable range[119] (40% and below) regarding study orientation in mathematics. For the 2000 group the profile (solid line) at the end of the POSC is still in the neutral range (40%-69%). This also applies to the 2001 group except for the fields Study attitude and Problem solving behaviour which are in the favourable range (70% and above). For the 2002 group the profile (solid line) at the end of the POSC is mainly in the favourable range (70% and above) and only the fields Mathematics confidence and Study environment are in the neutral range (40% to 69%).

[118] See Chapter 4 section 4.6.4 for detail on the interpretation of a study orientation profile.
[119] See Chapter 4 section 4.6.4 for detail on the terms "unfavourable", "neutral" and "favourable".

Regarding the sixth field, Information processing, the average scores in the end of course questionnaire for the 2000 and the 2001 groups are only marginally less than those in the beginning of course questionnaire (0.22 points less in the case of the 2000 group and 1.9 in the case of the 2001 group). In the same field the score for the 2002 group is 5.08 points higher in the end of course questionnaire. A possible explanation for the higher score in 2002 may be that during the research study in 2002 students were constantly encouraged and reminded to put into practice the aids and skills concerning learning and studying that they were introduced to in the POSC. These included constant reminders to the students to follow a healthy lifestyle (for example physical exercise and the intake of enough water), the use of mind maps, working in groups and reminding students about the advantages of whole brain usage. Overall, the profiles for all three the groups indicate an improvement in study orientation at the end of the POSC.

At the time of writing no published research on the use of the original SOM with first year tertiary students in mathematics was available. The version adapted for tertiary students, the SOMT, is now presented in the current study for the first time. Therefore, the results of this investigation regarding study orientation in tertiary mathematics, as measured by the SOMT, could not be corroborated with other research.

Figure 7-1 Group profiles representing the study orientation in mathematics of the 2000 POSC students

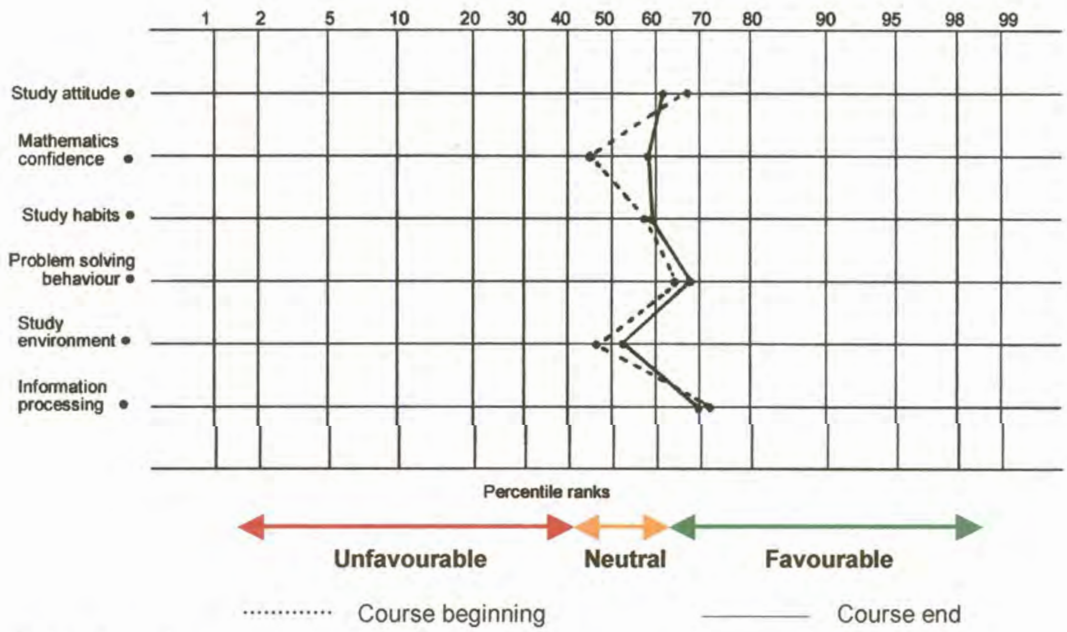

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Figure 7-2 Group profiles representing the study orientation in mathematics of the 2001 POSC students

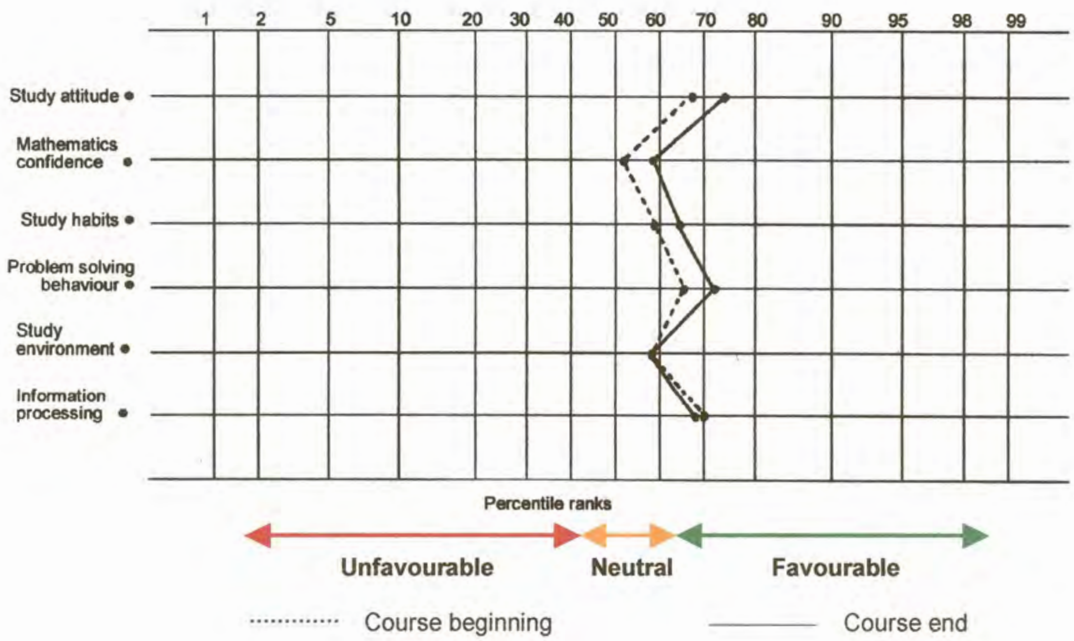

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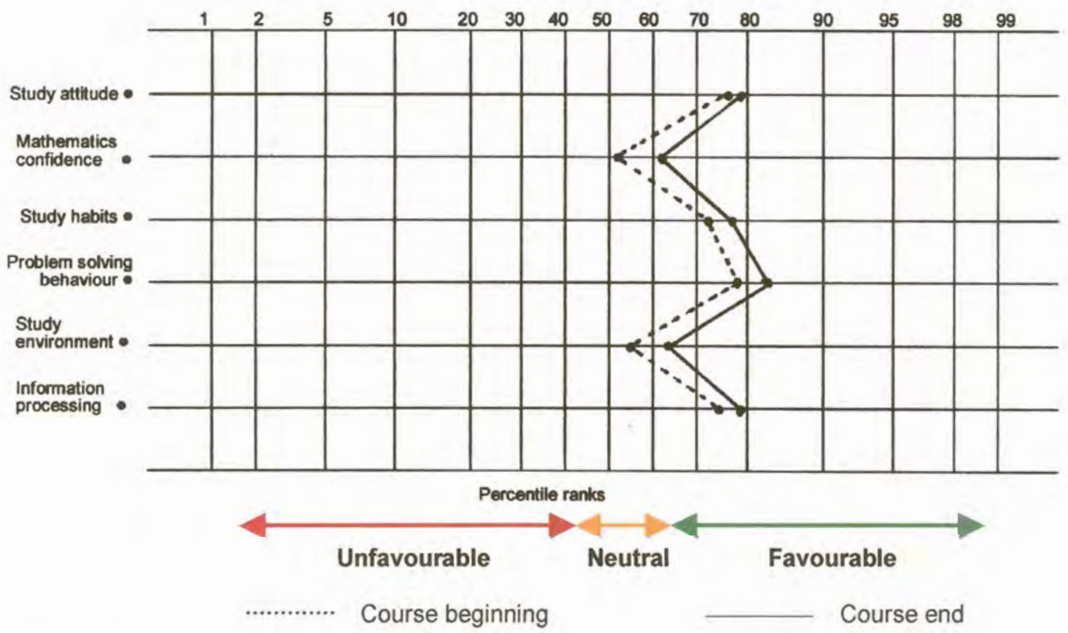
Figure 7-3 Group profiles representing the study orientation in mathematics of the 2002 POSC students



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7.1.2 Performance in mathematics

In Figure 7-4 the final marks in the standard first semester calculus course of first year engineering students during 2000, 2001 and 2002 are illustrated. These figures (as averages in percentages) give an indication of the performance in mathematics of students enrolled for the POSC compared to the performance of students on the regular 4YSP and to the performance of the other students on the 5YSP who are not enrolled for the POSC. In Figure 7-5 the average M-sores of the 2000 and 2001 groups are given.[120]

The data in Figure 7-4 indicates that the performance in standard first semester calculus course of the POSC students (left columns) compares favourably with those of the students on the regular 4YSP (right columns) and that the POSC group outperformed the other students on the 5YSP (middle columns).

When comparing the performance of the three groups in Figure 7-4, it must be kept in mind that all first year engineering students attend the same classes in the calculus course; that all the students on the 5YSP receive tutoring in mathematics but that the POSC students have the lowest M-score[121] of the three groups considered. The only difference between the three groups regarding their first semester mathematics experiences is that the POSC students are involved in the mathematics activities of the POSC that are structured according to the learning facilitation strategy proposed in this thesis.

The researcher is aware of the fact that in order to ascertain the real value of the effect of the support in a developmental approach as described in this thesis, the POSC students will have to be followed up further. Comparing first semester academic results (in mathematics) can lead to misinterpretation because of other variables present. However, a preliminary follow-up on the mathematics performance of the POSC students of 2000 and 2001 indicate that the trend in performance of the three groups is also noticeable for their performance in the second semester mathematics courses of the first year. In Figure 7-6 the final marks (as averages in percentages) in the first year mathematics courses are displayed for the POSC students, the other 5YSP students and the 4YSP students in 2000 and 2001.

[120] The M-score of the 2002 POSC group was not available at time of writing.
[121] The M-score of the POSC groups is usually approximately 7 points lower than that of the students on the 4YSP and 2-3 points lower than that of the other students on the 5YSP (Du Plessis, 2002).

It appears that the POSC students' enhanced ability in mathematics is not restricted to mathematics support given in the POSC during the first semester and that the composite approach followed in the proposed learning facilitation strategy contributes to the development of the mathematics potential of the learners.

Figure 7-4 Performance of first year engineering students in the standard first semester calculus course during 2000-2002

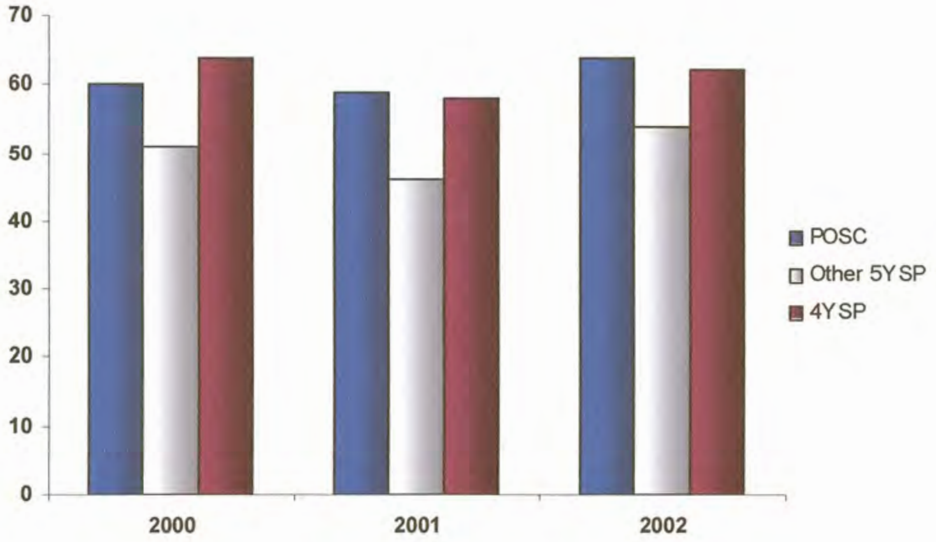

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Figure 7-5 Average M-scores of first year engineering students during 2000-2001

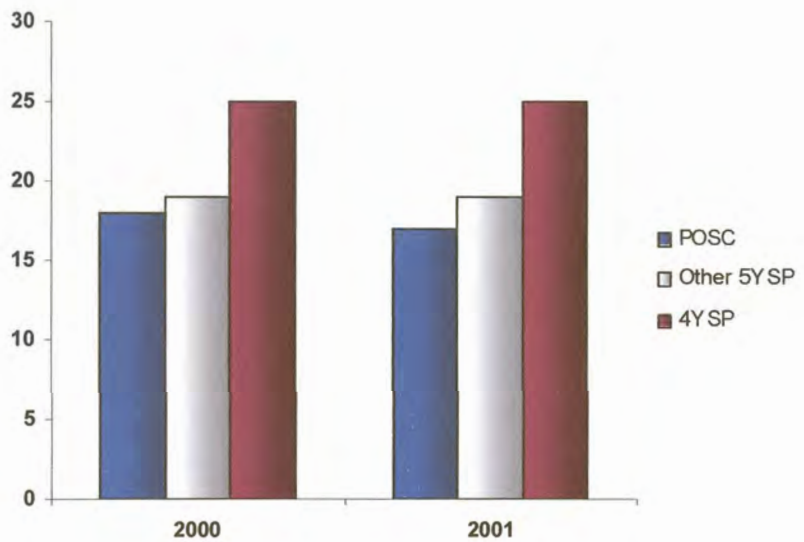

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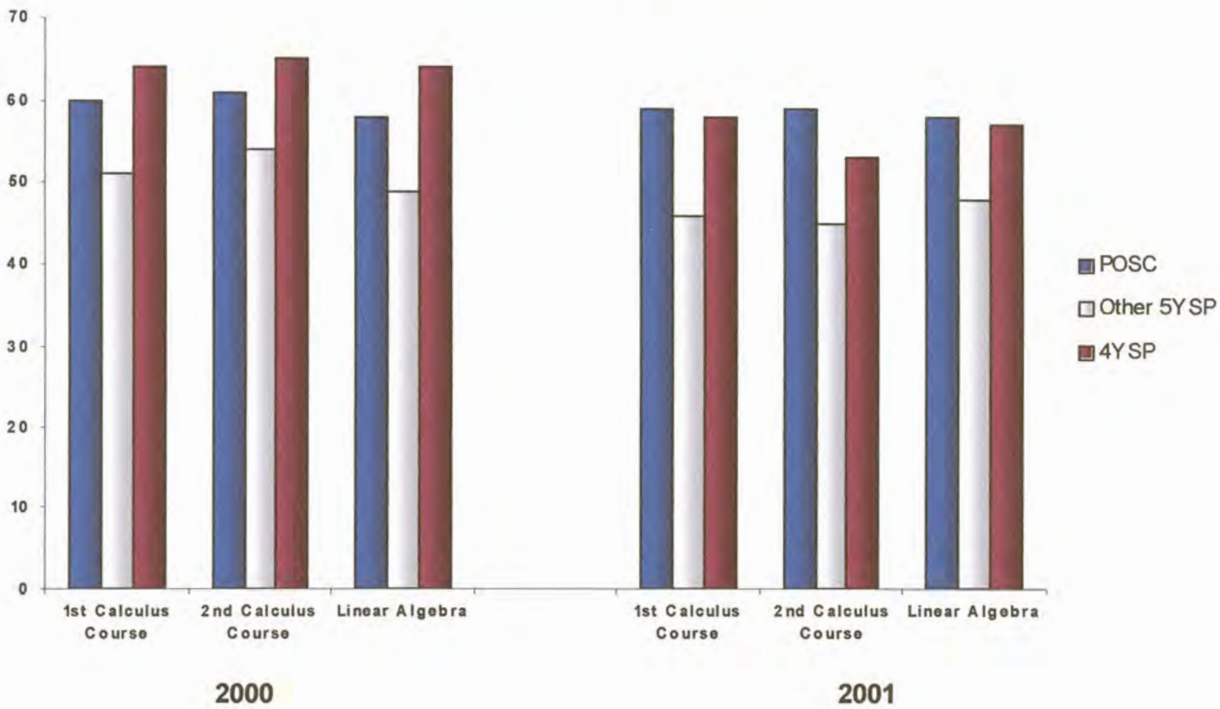
Figure 7-6 Performance of first year engineering students in the standard first year mathematics courses during 2000-2001



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7.1.3 Thinking style preferences of the POSC group

According to the results presented in Chapter 6 regarding the thinking style preferences of the POSC students the following can be deduced: No significant differences in thinking style preferences occur between the POSC students and the first year civil engineering students as measured by the HBDI. However, a significant difference in thinking style preferences regarding the A-quadrant of the Herrmann model occur between the two groups of engineering students on the one hand and the group of science students on the other. This finding corroborates previous research findings that engineers (engineering students) typically favour A-quadrant thinking (Herrmann, 1995 & 1996; Lumsdaine & Lumsdaine, 1995b; Lumsdaine *et al.*, 1999). For the purposes of this study the finding also highlights the fact that in spite of possible initial shortcomings in the educational background of the POSC students, they indeed display the same thinking style preferences (measured by the HBDI) as regular first year engineering students.

From inspection of the scores in the different quadrants[122] of the HBDI it is noticeable that for both the POSC and civil engineering students the score in the C-quadrant of the Herrmann model is the lowest. It can be speculated that this points to the fact that first year engineering students do not obviously or necessarily prefer activities associated with C-quadrant preferences as defined in the Herrmann model. According to Herrmann's model C-quadrant preferences are mostly feeling based and related to interactivity and communication (Herrmann, 1995, 1996, 1998). Herrmann (1995:83) remarks that a preference for the C-quadrant implies having *faith in groups and [being] open to the contribution of each person to a process or goal.* Although research has indicated that peer group learning works well, it seems as if first year engineering students need to be trained to work in groups and the classroom should be structured to foster interactivity.

Investigation of the individual profiles[123] of the POSC students indicates that the students have diverse thinking style preferences as measured by the HBDI. Furthermore, the preferences of the group, when combined, result in an average profile[124] that almost represents a generic whole brain profile. These findings are also in accordance with research that a group of individuals, on the one hand, represents diverse thinking preferences across all four quadrants of the Herrmann model and on the other, that the average profile of a group generally represents the generic whole brain profile displaying preference in all four the quadrants of the Herrmann model (Herrmann, 1995, 1996, 1998; Herrmann-Nedhi, 1999).

Investigation of the choices per category of the ILS[125] and a qualitative analysis thereof indicate, on the one hand, a diversity of learning style preferences as measured by the ILS, and on the other that the distribution of preferences is spread across all the categories of the ILS. At the time of writing and to the knowledge of the author no published research on the use of ILS with first year students on a support course was available and these qualitative findings could be neither compared nor corroborated with similar research.

The results above underscores, amongst other things, the aptness of using a composite strategy for learning facilitation that includes a whole brain approach whereby different thinking and learning styles are accommodated as well as promoted.

[122] See Chapter 6, Table 6-21 for the scores in the HBDI.
[123] See Chapter 2 section 4.6.6, Figure 4-8 for examples of individual profiles.
[124] See Chapter 6 section 6.6, Figure 6-1 A.
[125] See Chapter 6 section 6.8, Table 6-25, Table 6-2 and Table 6-27.

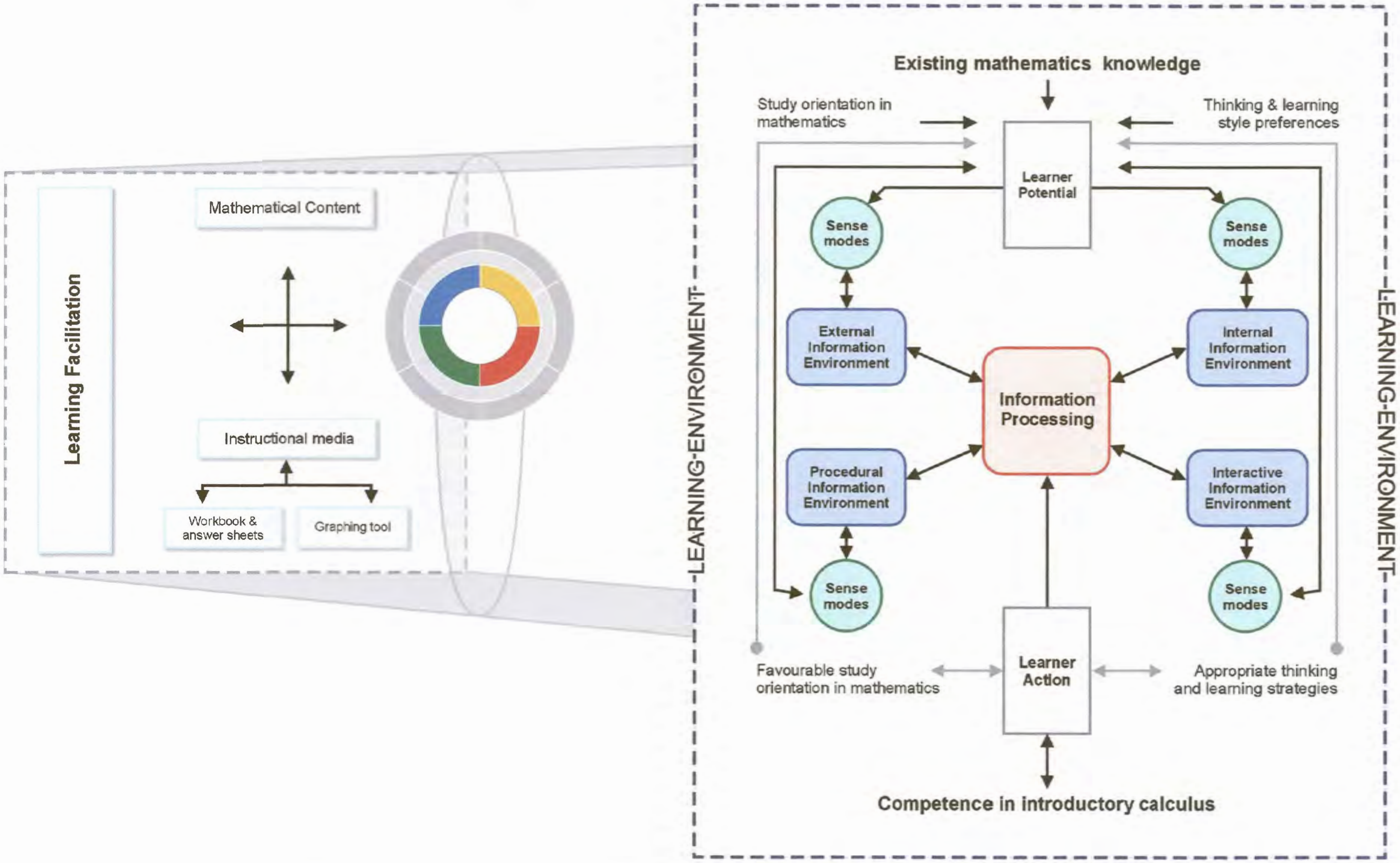
7.1.4 A strategy for learning facilitation of mathematics in a support course

The diagram in Figure 7-7 illustrates the learning facilitation strategy proposed and defined in this study. The main aspects that contribute to this strategy are summarised as follows:

- The strategy is multifaceted and comprises learning facilitation; the learner and the learning environment.
- Facilitation includes subject content; creating an awareness of thinking and learning preferences and of study orientation and fostering appropriate learning and thinking skills. Facilitation is further aimed at structuring the learning environment for effective and optimal information processing.[126]
- Aspects related to the learner include existing mathematics knowledge; mathematics potential; sense modes for information processing; a (latent) whole brain approach to learning; thinking and learning style preferences; study orientation in mathematics and learner action in terms of acquiring a more favourable study orientation in mathematics and appropriate thinking and learning strategies.[127]
- The learning environment includes, amongst other things, the physical personal and tertiary environment and the contribution and the influences of lecturers and the peer group towards a learner's experienced learning environment.[128]

[126] These aspects were discussed in Chapter 3 and in Chapter 5.
[127] These aspects were discussed in Chapter 2 and in Chapter 5.
[128] These aspects were discussed in Chapter 2, Chapter 3 and in Chapter 5.

Figure 7-7 A multifaceted and composite approach to the learning facilitation of mathematics in a support course



Proposed and compiled by the author

7.2 Limitations of the study

In general, the researcher acknowledges the fact that the present study was carried out with a relatively small group of participants; that the interpretation of the results is done within the context of the research topic and that another researcher working from a different perspective may interpret the same data in his/her own way.

However, it should be borne in mind that restricting a study to a specific group in a particular setting is one of the core aspects of action research *in order to improve the rationality and justice of [the] own ... educational practice, as well a [the] understanding of [the] practice and the situations in which [this] practice [is] carried out* (Kemmis & McTaggart, 1988:5).

In particular, the following limitations are acknowledged. Regarding the Study Orientation Questionnaire in Mathematics Tertiary (SOMT) that was developed in the present study from the existing Study Orientation Questionnaire in Mathematics (SOM), it should be pointed out that no factor analysis was done because the number of respondents to the SOMT was insufficient for this purpose. For the same reason, the norm table was not edited.

Regarding the proposed learning facilitation strategy, no specific attention in the research focused on the development of the sense modes (auditory, visual and kinaesthetic). However, it can be asserted that these competencies are inherently also developed when learners are engaged in the mathematical activities using the graphing tool, analysing visual images and formulating mathematical concepts verbally in their communication with the facilitator (and their peers) and in writing mathematics.

7.3 Conclusions

The primary objective of the research reported in this study was to define and implement a strategy for the learning facilitation of mathematics in a support course for first year engineering students. This goal was met as the aspects that constitute the strategy were defined and the strategy was implemented during 2000-2002. To determine the possible effects of this strategy, four research questions were investigated. These concerned determining the thinking and learning style preferences of the POSC students; their study orientation in mathematics at the beginning and the end of the POSC and their performance in mathematics. The effects of the proposed learning facilitation strategy were qualitatively and quantitatively investigated and interpreted. From these results it can be deduced that the combined aspects (illustrated in Figure 7-7) that constitute the learning facilitation strategy proposed in this thesis seemingly have a beneficial effect on the learners involved.

7.4 Recommendations

Although the aim of the study was met, a few aspects emerged in the course of the study that pose opportunities for further research. These include the need to further investigate the following:

- The possible use of the proposed learning facilitation strategy (or aspects thereof) with first year students (other than engineering students) enrolled for a support course in mathematics.

- The possible use of the proposed learning facilitation strategy (or aspects thereof) with first year students registered for a regular study programme.

- The implementation of the SOMT with a variety of students from different tertiary institutions in order to carry out a factor analysis on the SOMT.

- The possible adaptation of the SOMT as an electronic version including online scoring and immediate feedback.

- The use of the online version of the Felder Solomon Index of Learning Styles (ILS) to create an awareness of thinking and learning preferences and to compare preferences for mathematics learning to that of learning in other subjects. It is recommended that on one occasion the ILS can be done with the specific instruction to students to interpret the questions of the ILS as they apply to mathematics activities. This can then be followed up in a few weeks time by letting students interpret the questions of the ILS with regard to another subject. The distribution of preferences for a particular group and the possible differences in distribution of preferences according to the ILS for different subjects could also be investigated.

In addition to the recommendations regarding further research, the following remarks concerning the use of the proposed learning facilitation strategy (illustrated in Figure 7-7) are made:

- When surveys or questionnaires (such as the HBDI, ILS or SOMT) are used, they should be incorporated into activities as part of the learning facilitation strategy.

- In South Africa the administering of the HBDI is costly and not easily done as part of course activities. Therefore, it is recommended that the ILS is used so that students become aware of their own learning style preferences. The availability of the ILS as an accessible, online or paper-based, self scored instrument with immediate feedback contributes to its efficacy.

Lastly, by presenting the conclusions and giving suggestions for further research and practice, the intention is not to restrict the implications of the study to these aspects. In essence the author is of the opinion that the value of this study is in highlighting the effectiveness of a composite and multifaceted approach in the learning facilitation of mathematics when the development of the mathematics potential of a learner is at stake.