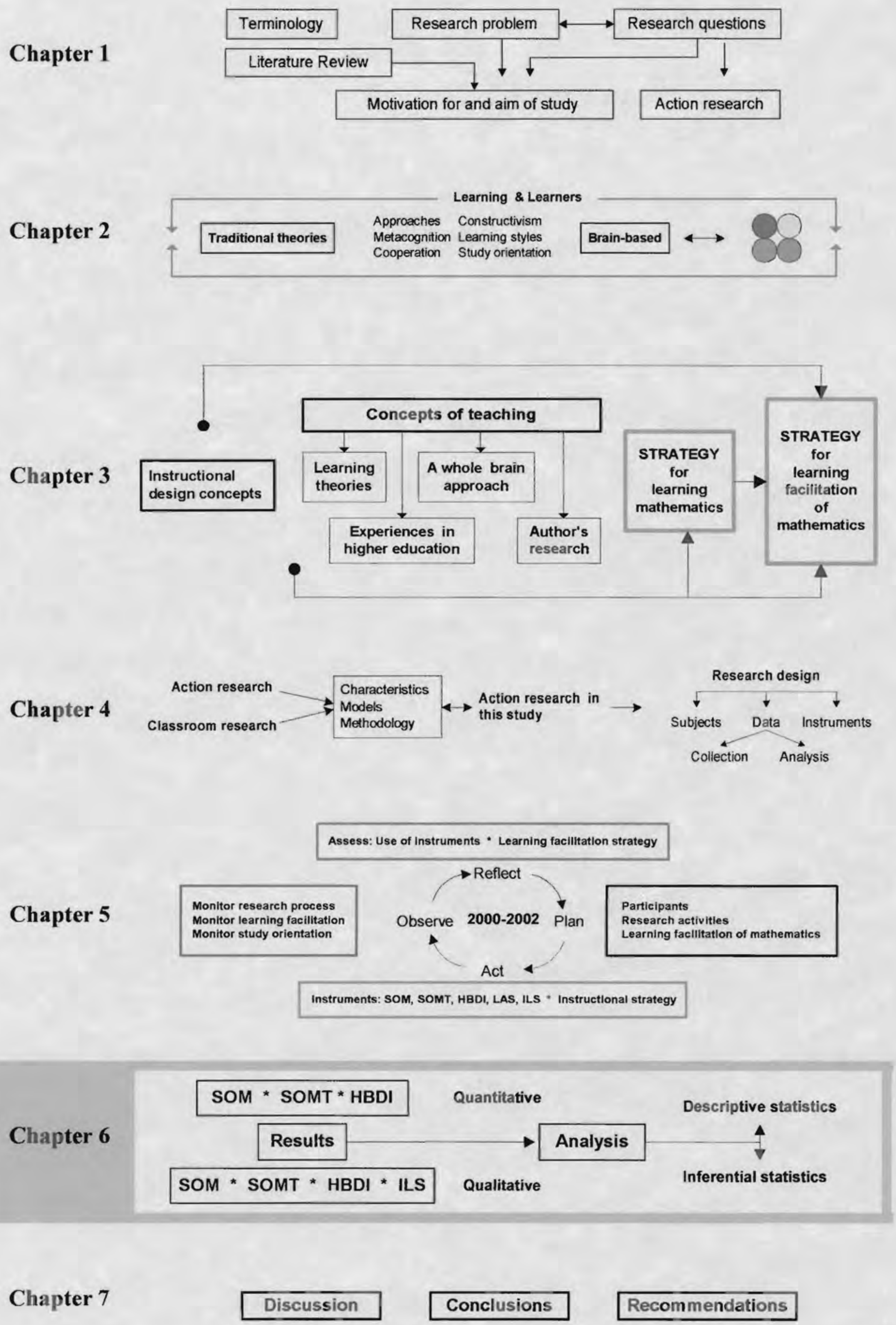
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Results and analysis

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Chapter 6

Results and analysis

6. Introduction

In Chapter 4 the research design of the present study and the procedures for the processing and reporting of the research data were discussed. The results of the study are presented in this chapter and analysis of the data given. This will be conducted as follows:

Firstly the results of item analyses of the Study Orientation Questionnaire in Mathematics Tertiary (SOMT) are given.

Then the results pertaining to the Study Orientation Questionnaire in Mathematics (SOM) and the Study Orientation Questionnaire in Mathematics Tertiary (SOMT) are given. The analysis of these results is done referring to the arithmetic mean, standard deviation and coefficient of variation. The data is given for the 2000, 2001 and 2002 POSC groups respectively.

The results of regression analysis are then given considering the relationship between the different fields of the SOM as a pre-intervention instrument and performance in the standard first semester calculus course for the 2000 and 2001 POSC groups. Results of regression analysis are also given regarding the relationship between the different fields of the SOMT as a pre-intervention instrument and performance in the standard first semester calculus course for the 2002 POSC group.

Correlations between mathematics performance and the different fields of the SOMT as post-intervention instrument are given for the 2000, 2001 and 2002 POSC groups respectively.

The difference between the scores in the fields of the Study Orientation Questionnaire in Mathematics at course beginning and at course end is compared for each of the 2000, 2001 and 2002 POSC groups separately. Then one-way analysis of variance is done to compare the differences in the arithmetic means of the fields of the Study Orientation Questionnaire in Mathematics as pre- and post-intervention instruments between the mentioned three POSC groups.

The means and standard deviations regarding the marks obtained in a first semester calculus course are given for the 2000, 2001 and 2002 POSC groups, the other students on the I and the engineering students on the regular 4YSP.

Then the results of the Herrmann Brain Dominance Instrument (HBDI) concerning students' thinking style preferences are given. These results include those of the 2000 POSC students and the first year civil engineering students of 2000 as well as that of a group of first year science students who did the HBDI during 1999.

The possible relationship between the results of the HBDI and the Lumsdaine and Lumsdaine learning activity survey (LAS) is considered concerning the 2000 POSC students and the first year civil engineering students of 2000.

Results regarding the Felder Soloman Index of Learning Styles (ILS) are qualitatively analysed for the 2001 and 2002 POSC groups.

A summary is given of aspects, identified by the POSC students themselves, that influence study orientation toward mathematics either positively or negatively.

Regarding the meaningfulness of results, McMillan and Schumacher (2001) remark that results should be *educationally significant, not just statistically significant* and that statistical significance does not necessarily imply educational significance. They also point out that meaningfulness is related to the specifics of a situation and that results are meaningful if they make a difference in the real world (McMillan & Schumacher, 2001:367). In the interpretation of the statistics regarding the research reported in this thesis, the mentioned views of McMillan and Schumacher are acknowledged.

For the purposes of the statistical conclusions in the current study, the Neyman-Pearson view on the results of an experiment is acknowledged. According to Howell (1997:94), in the Neyman-Pearson position one either rejects or *accepts* the null-hypothesis. *When we say that we "accept" a null-hypothesis ... we do not mean that we take it to be proven as true. We simple mean that we act as if it is true, at least until we have more adequate data.*

Phrases such as "retain the null hypothesis" and "fail to reject the null hypothesis" ... make clear the tentative nature of a nonrejection. (Howell, 1997:94).

Regarding the significance level of statistical results, Howell (1997:97) remarks that the opinion exists that more attention should be paid to the probability value itself and that in this alternative view one would think of $p = .051$ as "*nearly significant*" and of $p = .003$ as "*very significant*". In the assessment of the statistical results presented in the current study the significance level (rejection level) is taken as 5% throughout.

In the present study a distinction is made between a research hypothesis and statistical hypothesis. The convention is followed that in the case of a research hypothesis the expected outcome is stated and in the case of a statistical hypothesis a null hypothesis (H_0) and an alternative hypothesis (H_A) are stated.

6.1 Validity and reliability of the Study Orientation Questionnaire in Mathematics Tertiary (SOMT)

6.1.1 Validity of the SOMT: Item analysis

In order to determine the merit of the items in the SOMT for use with first year tertiary students on a support programme, three item analyses were performed on the 92 items of the SOMT. The ITEMAN™ Version 3.5 (ITEMAN ™, 1993) was used. In this study an item field correlation value of $r_{IF} \geq 0.30$ is regarded as a good value and a value of $0.20 \leq r_{IF} < 0.30$ is regarded a acceptable (Huysamen, 1996; Owen, 1995).

When analysing item test correlations, it should be borne in mind that a high item test correlation does not necessarily ensures content validity whereas a low item test correlation does not imply failure of the test. In this regard Cronbach (1971:457) remarks that

> *Low item correlations do not necessarily imply failure of the test content to fit the definition. Indeed, if the heterogeneous, consistently high intercorrelations imply inadequate sampling ... when the test constructor routinely discards the items whose intercorrelations with the total score for the pool are low, he risks making the tests less representative of the defined universe.*

As the SOMT is primarily based on the SOM the content validity of the SOMT is assumed *a priori*. Maree (2000) and Claassen (2001) who were involved in compiling the original SOM agree that the validity of the SOMT can be accepted for use with first year tertiary students. However, the three item analyses were carried out to ensure that the changes which had been made to the wording of some of the questions[106] properly convey the meaning of the questions as intended.

In Table 6-1 the final item analysis for the SOMT-1[107] is given for the 2000 and 2001 POSC groups combined. In Table 6-2 the item analysis for the SOMT-2 for the 2002 POSC group is given and in Table 6-3 the item analysis for the SOMT-3 for the 2002 POSC group is given.

Table 6-1 Final item analysis of the SOMT for the POSC 2000 and 2001 groups combined (N=61)

		Scale (% endorsing)							
Field	**Item**	**0**	**1**	**2**	**3**	**4**	**Mean**	**Variance explained**	**Item field correlation**
1	1	0	5	15	38	43	4.180	0.738	0.64
Study attitude	6	0	0	5	33	62	4.574	0.343	0.59
	16	0	5	7	43	46	4.295	0.634	0.47
	21	0	2	8	15	75	4.639	0.493	0.49
	28	0	5	5	33	57	4.426	0.638	0.60
	33	0	0	3	26	73	4.672	0.286	0.42
	38	0	10	15	38	38	4.033	0.917	0.38
	43	8	25	15	36	16	3.279	1.512	0.70
	48	3	11	5	36	44	4.066	1.242	0.56
	55	13	16	20	30	21	3.295	1.749	0.46
	60	13	16	23	31	16	3.213	1.610	0.44
	65	0	15	11	25	49	4.082	1.190	0.34
	70	0	10	23	31	36	3.934	0.979	0.57

[106] See Chapter 4, Section 4.6.5 for details on the adaptation of the SOM to the SOMT.
[107] The different versions of the SOMT are discussed in Chapter 4.

Field	Item	Scale (% endorsing)					Mean	Variance explained	Item field correlation
		0	1	2	3	4			
2	2	3	2	16	46	33	4.033	0.851	0.45
Mathematic confidence	7	3	11	16	33	36	3.869	1.261	0.47
	12	3	8	7	31	51	4.180	1.164	0.46
	17	2	7	10	38	44	4.164	0.924	0.35
	22	2	2	7	8	82	4.672	0.647	0.48
	29	10	8	8	30	44	3.902	1.728	0.69
	34	13	18	16	28	25	3.328	1.860	0.55
	39	5	10	21	25	39	3.836	1.416	0.62
	56	2	0	3	3	92	4.836	0.399	0.32
	61	5	31	21	39	3	3.049	1.030	0.53
	66	0	5	3	16	75	4.623	0.596	0.35
	71	28	23	8	18	23	2.852	2.421	0.55
3	3	2	10	25	28	36	3.869	1.130	0.50
Study habits	8	2	30	20	31	18	3.344	1.275	0.59
	13	3	7	10	31	49	4.164	1.121	0.58
	18	0	18	10	36	36	3.902	1.171	0.47
	23	10	28	21	33	8	3.016	1.328	0.63
	27	0	3	7	34	56	4.426	0.572	0.63
	30	0	8	8	30	54	4.295	0.864	0.65
	35	0	10	13	28	49	4.164	0.990	0.62
	40	0	13	13	38	36	3.967	1.015	0.64
Study habits	45	5	20	21	38	16	3.410	1.258	0.43
	50	23	30	16	18	13	2.689	1.821	0.54
	54	0	16	15	36	33	3.852	1.109	0.65
	57	3	11	10	28	48	4.049	1.325	0.58
	62	1	3	18	48	23	3.787	0.987	0.63
	67	8	11	23	30	28	3.574	1.523	0.27
	72	2	13	25	30	31	3.754	1.169	0.63
	74	2	8	15	39	46	4.098	1.072	0.69
4	4	7	38	18	26	11	2.984	1.360	0.65
Problem solving behaviour	9	7	23	25	28	18	3.279	1.414	0.69
	14	0	8	21	59	11	3.783	0.587	0.59
	19	2	10	23	34	31	3.836	1.055	0.69
	24	8	26	18	33	15	3.197	1.469	0.25
	26	0	10	11	46	33	4.016	0.836	0.56
	31	5	18	21	51	5	3.328	0.974	0.58
	36	15	34	26	21	3	2.639	1.149	0.65
	41	7	13	16	39	25	3.623	1.382	0.64

Field	Item	Scale (% endorsing) 0	1	2	3	4	Mean	Variance explained	Item field correlation
Problem solving behaviour	46	2	10	23	34	31	3.836	1.055	0.71
	51	3	16	21	30	30	3.656	1.340	0.52
	53	0	3	3	23	70	4.607	0.501	0.47
	58	21	28	16	21	13	2.770	1.816	0.56
	63	15	30	15	26	15	2.967	1.737	0.70
	68	30	33	16	15	7	2.361	1.509	0.58
	75	0	15	15	31	39	3.951	1.129	0.71
5	10	8	15	7	33	38	3.770	1.718	0.55
Study environment	15	11	15	25	26	23	3.344	1.668	0.58
	20	2	3	7	18	70	4.525	0.774	0.41
	25	23	34	10	20	13	2.656	1.865	0.57
	37	3	2	2	7	87	4.721	0.726	0.29
	42	2	3	3	30	62	4.475	0.708	0.43
	47	0	0	3	41	56	4.525	0.315	0.35
	52	3	15	11	33	38	3.869	1.360	0.68
	59	2	7	5	44	43	4.197	0.847	0.22
	64	3	7	8	28	54	4.230	1.128	0.48
	69	3	2	15	34	46	4.180	0.935	0.44
6	77	5	8	20	56	11	3.607	0.927	0.44
Information processing	79	3	8	23	43	23	3.738	1.013	0.36
	80	5	18	15	54	8	3.426	1.064	0.37
	81	3	11	16	46	23	3.738	1.079	0.45
	82	2	7	16	46	30	3.951	0.866	0.66
	83	3	31	18	28	20	2.295	1.421	0.41
	84	0	5	10	41	44	4.246	0.677	0.52
	85	3	15	33	26	23	3.508	1.201	0.47
	86	0	5	10	48	38	4.180	0.640	0.47
	87	0	7	15	46	33	4.049	0.735	0.68
	88	0	7	18	51	25	3.934	0.684	0.57
	89	0	2	3	36	59	4.525	0.413	0.56
	90	8	16	25	34	16	3.344	1.373	0.43
	91	0	3	2	31	64	4.557	0.476	0.36
	92	11	20	26	38	5	3.049	1.227	0.55

The item analysis presented in Table 6-1 was analysed and questions 11, 32, 44 and 49 had field correlation values $r_{IF} < 0.20$. These questions were carefully considered in order to ascertain possible reasons for the low correlation values. Question 11 was left unchanged. The wording of questions 32, 44 and 49 were adapted. These changes are detailed in Chapter 4 Table 4-14. These adjustments were implemented in the SOMT-2. The item analysis of the SOMT-2 is given in Table 6-2.

Table 6-2 Item analysis of the SOMT-2 for the 2002 POSC group (N=50)

		Scale (% endorsing)							
Field	**Item**	**0**	**1**	**2**	**3**	**4**	**Mean**	**Variance explained**	**Item field correlation**
1	1	0	8	16	34	42	4.100	0.890	0.56
Study attitude	6	2	2	6	36	54	4.380	0.716	0.35
	11	4	4	6	18	68	4.420	1.084	0.20
	16	4	4	10	20	62	4.320	1.138	0.47
	21	2	0	2	18	78	4.700	0.490	0.39
	28	2	0	0	24	74	4.680	0.458	0.16
	33	0	2	2	28	68	4.620	0.396	0.28
	38	6	12	20	26	36	3.740	1.512	0.39
	43	12	12	16	34	26	3.500	1.730	0.62
	48	6	10	6	18	60	4.160	1.574	0.55
	55	6	16	10	44	24	3.640	1.390	0.37
	60	2	6	6	50	36	4.012	0.826	0.35
	65	2	10	10	40	38	4.020	1.060	0.46
	70	0	0	10	30	60	4.500	0.450	0.19
2	2	2	14	12	58	14	3.680	0.898	0.46
Mathematic confidence	7	2	14	32	20	32	3.660	1.264	0.30
	12	2	12	0	34	52	40220	1.132	0.37
	17	2	10	12	28	48	4.100	1.170	0.50
	22	2	4	4	16	74	4.560	0.806	0.48
	29	8	22	10	24	36	3.580	1.884	0.42
	34	18	16	26	28	12	3.000	1.640	0.66
	39	12	10	12	34	32	3.640	1.790	0.54
	44	0	0	4	12	84	4.800	0.240	0.34
	49	0	0	4	20	76	4.720	0.282	0.18
	56	4	6	2	14	74	4.480	1.130	0.32
	61	4	20	38	38	0	3.100	0.730	0.44
	66	0	2	10	20	68	4.540	0.568	0.43
	71	22	24	10	14	30	3.060	2.456	0.44

		Scale (% endorsing)							
Field	Item	0	1	2	3	4	Mean	Variance explained	Item field correlation
3	3	2	8	12	40	38	4.040	0.998	0.44
Study habits	8	12	12	24	28	24	3.400	1.680	0.64
	13	0	2	2	20	76	4.700	0.370	0.44
	18	0	8	12	44	36	4.080	0.794	0.47
	23	8	10	20	38	24	3.600	1.400	0.60
	27	0	0	8	20	72	4.640	0.390	0.25
	30	0	2	6	26	66	4.560	0.486	0.39
	35	0	4	4	42	50	4.380	0.556	0.29
	40	2	10	14	20	54	4.140	1.240	0.51
Study habits	45	4	16	10	34	36	3.820	1.428	0.58
	50	24	24	14	24	14	2.800	1.960	0.51
	54	2	2	22	38	36	4.040	0.838	0.58
	57	2	0	12	30	56	4.380	0.716	0.63
	62	4	6	18	42	30	3.880	1.066	0.53
	67	8	18	12	28	34	3.620	1.756	0.67
	72	10	8	20	48	14	3.480	1.290	0.58
	74	0	4	10	42	44	4.260	0.632	0.61
4	4	10	26	22	30	12	3.080	1.434	0.70
Problem solving behaviour	9	6	24	26	30	14	3.220	1.292	0.63
	14	2	6	18	58	16	3.800	0.720	0.48
	19	8	4	8	46	34	3.940	1.296	0.65
	24	10	26	12	028	24	3.300	1.810	0.29
	26	0	4	10	26	60	4.420	0.684	0.53
	31	4	22	22	42	10	3.320	1.098	0.42
	36	22	32	20	20	6	2.560	1.446	0.64
	41	4	2	24	28	42	4.020	1.100	0.32
	46	2	6	12	36	44	4.140	0.960	0.50
	51	8	12	16	32	32	3.680	1.578	0.45
	53	0	4	2	18	76	4.660	0.504	0.09
	58	6	34	18	18	24	3.200	1.680	0.45
	63	8	26	18	32	16	3.220	1.492	0.67
	68	24	30	14	22	10	2.640	1.750	0.57
	73	2	8	16	38	36	3.980	1.020	0.22
	75	2	2	12	54	30	4.080	0.674	0.46
	76	6	6	18	34	36	3.880	1.306	0.19

		Scale (% endorsing)							
Field	**Item**	**0**	**1**	**2**	**3**	**4**	**Mean**	**Variance explained**	**Item field correlation**
5	5	2	4	2	30	62	4.460	0.768	0.38
Study environment	10	6	16	6	32	40	3.840	1.614	0.66
	15	18	16	16	30	20	3.180	1.948	0.53
	20	2	0	6	26	66	4.540	0.608	0.65
	25	28	28	14	20	10	2.560	1.806	0.45
	32	2	2	4	12	80	4.660	0.664	0.42
	37	2	6	10	16	66	4.380	1.036	0.50
	42	0	4	8	24	64	4.480	0.650	0.59
	47	0	4	8	28	60	4.440	0.646	0.28
	52	6	8	8	38	40	3.980	1.340	0.65
	59	0	12	6	42	40	4.100	0.930	0.29
	64	4	4	6	32	54	4.280	1.042	0.50
	69	4	8	8	38	42	4.060	10176	0.37
6	77	4	8	10	56	22	3.840	0.974	0.51
Information processing	78	4	2	24	52	18	3.780	0.812	0.38
	79	2	2	10	42	44	4.240	0.742	0.50
	80	2	16	14	46	22	3.700	1.090	0.54
	81	2	18	18	42	20	3.600	1.120	0.43
	82	2	2	14	52	30	4.060	0.696	0.66
	83	8	16	24	36	16	3.360	1.350	0.44
	84	4	2	6	38	50	4.280	0.922	0.63
	85	6	10	28	26	30	3.640	1.390	0.43
	86	0	4	10	52	34	4.160	0.574	0.69
	87	2	4	16	52	26	3.960	0.758	0.56
	88	0	2	14	58	26	4.080	0.474	0.64
	89	0	2	4	32	62	4.540	0.448	0.64
	90	6	8	18	40	28	3.760	1.262	0.47
	91	0	0	8	24	68	4.600	0.400	0.50
	92	20	18	32	24	6	2.780	1.412	0.70

Again the results of the item analysis presented in Table 6-2 were analysed. No questions were removed, but changes were made to the wording of questions 11 and 49. These changes are detailed in Chapter 4 Table 4-12. These adjustments were implemented in the SOMT-3.

The item analysis of the SOMT-3 is given in Table 6-3.

Table 6-3 Item analysis of the SOMT-3 for the 2002 POSC group (N=48)

		Scale (% endorsing)							
Field	Item	0	1	2	3	4	Mean	Variance explained	Item field correlation
1	1	0	0	9	43	49	4.404	0.411	0.75
Study attitude	6	2	2	4	19	72	4.574	0.713	0.27
	11	2	0	2	28	68	4.596	0.539	0.25
	16	0	9	6	32	53	4.298	0.847	0.49
	21	2	0	6	17	74	4.617	0.619	0.36
	28	2	0	6	28	64	4.511	0.633	0.30
	33	0	0	9	19	72	4.638	0.401	0.65
	38	0	4	21	40	34	4.043	0.722	0.34
	43	4	2	23	49	21	3.809	0.878	0.47
	48	0	11	4	34	51	4.255	0.914	0.71
	55	4	6	23	49	17	3.681	0.941	0.30
	60	4	15	21	30	30	3.660	1.373	0.70
	65	2	9	4	36	49	4.213	1.019	0.48
	70	0	2	9	36	53	4.404	0.539	0.38
2	2	0	4	11	43	43	4.234	0.674	0.47
Mathematic confidence	7	0	11	17	38	34	3.957	0.934	0.22
	12	4	2	6	36	51	4.277	0.966	0.19
	17	2	9	2	40	47	4.213	0.976	0.55
	22	2	4	4	6	83	4.638	0.827	0.47
	29	9	6	9	26	51	4.043	10615	0.49
	34	6	13	17	45	19	3.574	1.266	0.61
	39	4	9	13	47	28	3.851	1.105	0.50
	44	2	0	0	17	81	4.745	0.445	0.47
	49	0	4	9	28	60	4.426	0.670	0.49
	56	0	4	0	19	77	4.681	0.473	0.29
	61	6	19	26	45	4	3.213	1.019	0.29
	66	2	0	6	30	62	4.489	0.633	0.44
	71	19	19	6	19	36	3.340	2.480	0.58
3	3	0	2	4	34	60	4.511	0.463	0.48
Study habits	8	0	9	23	40	28	3.872	0.835	0.48
	13	2	0	9	30	60	4.447	0.673	0.51
	18	0	6	15	34	45	4.170	0.822	0.41
	23	6	11	19	40	23	3.638	1.295	0.65
	27	0	0	2	26	72	4.702	0.252	0.40
	30	0	2	4	32	62	4.532	0.462	0.47
	35	2	2	15	34	47	4.213	0.848	0.66
	40	2	4	9	34	51	4.277	0.881	0.71

Field	Item	Scale (% endorsing) 0	1	2	3	4	Mean	Variance explained	Item field correlation
Study habits	45	2	9	9	40	40	4.085	1.014	0.43
	50	13	9	21	43	15	3.383	1.470	0.50
	54	2	9	21	40	28	3.830	0.992	0.52
	57	4	2	9	28	57	4.319	1.026	0.39
	62	0	9	15	23	53	4.213	0.976	0.47
	67	4	17	17	28	34	3.702	1.486	0.51
	72	2	4	17	34	43	4.106	0.946	0.62
	74	0	4	15	30	51	4.277	0.753	0.60
4	4	6	32	30	23	9	2.957	1.147	0.76
Problem solving behaviour	9	4	26	28	36	6	3.149	1.020	0.57
	14	2	11	26	43	19	3.660	0.948	0.39
	19	2	6	9	53	30	4.021	0.829	0.48
	24	9	15	21	34	21	3.447	1.481	0.38
	26	0	2	6	40	51	4.404	0.496	0.43
	31	11	19	17	40	13	3.255	1.467	0.53
	36	11	32	23	28	6	2.872	1.260	0.69
	41	0	2	6	36	55	4.447	0.502	0.19
	46	0	0	17	45	38	4.213	0.508	0.47
	51	4	6	11	21	57	4.213	1.274	0.43
	53	0	2	9	11	79	4.660	0.522	0.22
	58	13	17	13	45	13	3.277	1.562	0.63
	63	6	19	17	34	23	3.489	1.484	0.72
	68	17	21	23	17	21	3.043	1.913	0.48
	73	4	2	15	47	32	4.000	0.936	0.34
	75	2	7	20	37	35	3.957	0.998	0.71
	76	2	0	15	43	40	4.191	0.708	0.25
5	5	2	9	4	32	53	4.255	1.041	0.38
Study environment	10	6	6	9	34	45	4.043	1.360	0.37
	15	6	6	9	34	45	4.043	1.360	0.76
	20	2	4	0	23	70	4.533	0.785	0.52
	25	9	30	28	13	21	3.085	1.610	0.68
	32	2	0	0	19	79	4.723	0.455	0.24
	37	2	2	4	28	64	4.489	0.718	0.34
	42	2	0	0	26	72	4.4660	0.480	0.45
	47	0	0	2	55	43	4.404	0.283	0.33
	52	2	6	19	30	43	4.043	1.062	0.69
	59	0	6	9	53	32	4.106	0.648	0.53
	64	6	9	2	19	64	4.255	1.509	0.68
	69	6	2	9	26	57	4.255	1.254	0.39

		Scale (% endorsing)							
Field	**Item**	**0**	**1**	**2**	**3**	**4**	**Mean**	**Variance explained**	**Item field correlation**
6	77	2	9	13	53	23	3.872	0.877	0.55
Information processing	78	2	4	21	40	32	3.957	0.892	0.53
	79	0	4	17	34	45	4.191	0.751	0.47
	80	6	4	9	60	21	3.851	1.020	0.19
	81	2	11	11	34	43	4.043	1.147	0.67
	82	4	4	9	38	45	4.149	1.063	0.72
	83	4	21	23	32	19	3.404	1.305	0.43
	84	0	4	0	38	57	4.489	0.505	0.53
	85	2	17	11	28	43	3.915	1.139	0.53
	86	2	4	4	40	49	4.289	0.805	0.42
	87	0	4	17	34	45	4.191	0.751	0.66
	88	2	4	13	49	32	4.043	0.807	0.54
	89	0	2	4	34	60	4.511	0.463	0.57
	90	6	9	11	43	32	3.851	1.318	0.35
	91	0	2	0	32	66	4.617	0.364	0.35
	92	13	9	19	49	11	3.362	1.380	0.61

The results of the item analysis presented in Table 6-3 indicate that the questions, which were adapted[108] from the previous version of the questionnaire, loaded well in the respective fields. Two questions (numbers 41 and 80) did not discriminate well although they loaded well in the respective fields of the previous item analyses (see Table 6-1 and Table 6-2).

Regarding question 41 in the field Problem solving behaviour, most of the students chose the option, 'almost always'. This choice could be expected if one considers that the interventions of the learning facilitation strategy followed in the POSC are successful. Regarding question 80 in the field Information processing, most of the students chose the option 'generally'. Again this choice is reasonable as one expects that the learners involved in the interventions of the POSC should realise that they have to prepare for their mathematics tests.

[108] The adaptations are listed in Table 4-11 to Table 4-15.

6.1.2 Reliability of the SOMT

The reliabilities of the different fields of the SOMT were determined with the Cronbach alpha coefficients. In Table 6-4 the Cronbach alpha coefficients for the fields of the three versions of the SOMT are given. The SOMT-1 was used as a post-intervention instrument (at the beginning of the POSC) with the 2000 and 2001 POSC groups. The SOMT-2 was used as a pre-intervention instrument (at the beginning of the POSC) with the 2002 POSC group and the SOMT-3 was used as a post-intervention instrument (after the POSC) with the 2002 POSC group.

Table 6-4 Cronbach alpha coefficients for the fields of the SOMT

	SOMT-1	SOMT-2	SOMT-3
Field	N=61	N=50	N=47
1 Study attitude (SA)	0.576 (≈0.6)	0.576 (≈0.6)	0.711 (≈0.7)
2 Mathematics confidence (MC)	0.654 (≈0.7)	0.654 (≈0.7)	0.664 (≈0.7)
3 Study habits (SH)	0.828 (≈0.8)	0.828 (≈0.8)	0.825 (≈0.8)
4 Problem solving behaviour (PSB)	0.783 (≈0.8)	0.783 (≈0.8)	0.813 (≈0.8)
5 Study environment (SE)	0.721 (≈0.7)	0.721 (≈0.7)	0.747 (≈0.7)
6 Information processing (IP)	0.827 (≈0.8)	0.827 (≈0.8)	0.802 (≈0.8)

According to the data in Table 6-4 the Cronbach alpha coefficients range between 0.6 and 0.8, for the fields of the SOMT-1 and the SOMT-2 and between 0.7 and 0.8 and for the fields of the SOMT-3. The value of the coefficients can be regarded as acceptable for the purpose for which the questionnaire was used. Although McMillan and Schumacher (2001) remark that one should be wary of reliabilities below 0.7 they point out that several factors should be considered when interpreting reliability coefficients. According to them, reliability is higher if a group is more heterogeneous regarding the trait that is measured; if the number of items in a instrument is high; if the range of scores is substantially large and if items discriminate between high and low achievement (McMillan & Schumacher, 2001:247-248).

Using McMillan and Schumacher's guideline for the minimum value of reliabilities, it is clear from Table 6-4 that in the final version of the SOMT (SOMT-3), as adapted and used in this research, all the fields comply with McMillan and Schumacher's (2001) minimum Cronbach alpha coefficient value of 0.7.

In Table 6-5 the main research hypotheses together with the sections in this chapter in which they are treated are listed.

Table 6-5 Section references where the main research hypotheses are treated

	Main research hypothesis	Chapter section
1	A relationship exists between the fields of the Study Orientation Questionnaire in Mathematics and performance in the standard first semester course in calculus.	6.2
2	Significant differences exist between the arithmetic means of the fields of the Study Orientation Questionnaire in Mathematics at the beginning of the POSC and after the POSC.	6.4
3	No significant differences exist between the means of the fields of the Study Orientation Questionnaire in Mathematics as pre- and post-intervention instruments between the different groups.	6.5
4	The average mark achieved by the POSC group in a standard first semester calculus course is higher than the average mark of students not enrolled for the POSC.	6.3
5	The thinking style preferences of first year engineering students enrolled for a support course represent preferences distributed across all four quadrants of the Herrmann whole brain model.	6.6

In Table 6-6 on the following pages an overview is given of the research questions, the relevant research hypotheses, the details of the individual sub-hypotheses and the numbers by which the statistical hypotheses are treated in this chapter as well as the statistical information pertaining to the investigation of each of the hypotheses.

Table 6-6 Research questions and relevant research hypotheses

Research question	Main hypothesis	Sub-hypothesis	Number	Independent variables	Dependent variables	Statistical procedure
Research question 1: What is the study orientation towards mathematics of the students enrolled for the POSC? **Research question 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?	**Main hypothesis 1:** A relationship exists between the fields of the Study Orientation Questionnaire in Mathematics and performance in the standard first semester course in calculus.	The scores in the different fields of the SOM can be regarded as predictors of students' marks in mathematics	H1-1	Scores in the different fields of the SOM	Mark in the standard first semester course in calculus for the 2000 POSC group 2001 POSC group	Regression analysis
		The scores in the different fields of the SOMT can be regarded as predictors of students' marks in mathematics	H1-2	Scores in the different fields of the SOMT	Mark in the standard first semester course in calculus for the 2002 POSC group	Regression analysis
		Significant correlations exist between the different fields of the SOMT and the performance in the standard first semester course in calculus.	H1-3	Scores in the different fields of the SOMT	Mark in the standard first semester course in calculus for the 2000 POSC group 2001 POSC group 2002 POSC group	Pearson correlation

Table 6-6 continues on the next page.

Table 6-6 Research questions and relevant research hypotheses (continued)

Research question	Main hypothesis	Sub-hypothesis	Number	Group	Variable	Statistical procedure
Research question 1: What is the study orientation towards mathematics of the students enrolled for the POSC?	**Main hypothesis 2:** Significant differences exist between the arithmetic means of the fields of the Study Orientation Questionnaire in Mathematics at the beginning of the POSC and after the POSC.	None	H2	2000 POSC 2001 POSC 2002 POSC	Arithmetic means for the different fields of the SOM/SOMT	Wilcoxon test
Research question 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?	**Main hypothesis 3:** No significant differences (post- minus pre-intervention) exist in the means of the three POSC groups for the fields of the Study Orientation Questionnaire in Mathematics.	None	H3	2000 POSC 2001 POSC 2002 POSC	Differences between the arithmetic means of the different fields of the SOM/SOMT	ANOVA

Table 6-6 continues on the next page.

Table 6-6 Research questions and relevant research hypotheses (continued)

Research question	Main hypothesis	Sub-hypothesis	Number	Group	Variable	Statistical procedure
Research Question 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?	**Main hypothesis 4:** The average mark achieved by the POSC group in a standard first semester calculus course is higher than the average mark of students not enrolled for the POSC.	None		2000 POSC 2000 Other 5YSP 2000 4YSP 2001 POSC 2001 4YSP 2001 Other 5YSP 2002 POSC 2002 4YSP 2002 Other 5YSP	Performance in the first semester course in calculus	Mean, standard deviation

Table 6-6 continues on the next page.

Table 6-6 Research questions and relevant research hypotheses (continued)

Research question	Main hypothesis	Sub-hypothesis	Number	Group	Variables	Statistical procedure
Research question 4: What are the thinking style preferences of first year engineering students enrolled for the POSC?	**Main hypothesis 5:** The thinking style preferences of first year engineering students enrolled for a support course represent preferences distributed across all four quadrants of the Herrmann whole brain model.	Differences exist in the arithmetic means of the scores for the quadrants of the HBDI between the POSC group, the civil engineering group and science students on a support course.	H4	2000 POSC 2000 First year civil engineering students 1999 First year science students	Different quadrants of the HBDI	Kruskal-Wallis test
		Significant correlations exist between the quadrants of the HBDI and the corresponding sections of the LAS		2000 POSC 2000 First year civil engineering students	Different quadrants of the HBDI Different sections of the LAS	Pearson correlation

6.2 Results: SOM and the SOMT

6.2.1 Descriptive statistics: Mean and standard deviation

Table 6-7 gives the arithmetic mean ($\bar{x}$), standard deviation (s) and coefficient of variation ($cv = \frac{s}{\bar{x}} \times 100\,\%$) regarding the SOM as a pre-intervention instrument and the SOMT-1 as a post-intervention instrument for the 2000 POSC group. Table 6-8 gives the same data for the 2001 POSC group. In Table 6-9 the same data regarding the SOMT-2 as a pre-intervention instrument and the SOMT-3 as a post-intervention instrument for the 2002 POSC group is given. The data was statistically processed using the SAS program, Version 8 (SAS, 1990).

Regarding the processing of the scores on the different fields of the questionnaires, the following should be noted. The arithmetic means are given as the means of percentile ranks.[109] In addition to the standard deviation, the coefficient of variation was used as a relative measure to investigate the precision of the arithmetic mean in order to determine the density of the values around the mean. A relatively large value for the coefficient of variation indicates less precision denoting that the scores are less dense around the arithmetic mean.

[109] See Chapter 4 section 4.6.4 for information on the percentile ranking and the scoring of the SOM/SOMT.

Table 6-7 The arithmetic mean, standard deviation and coefficient of variation regarding the SOM/SOMT for the 2000 POSC group

	2000 POSC					
	SOM (Pre-intervention) (N=30)			SOMT-1 (Post-intervention) (N=26)		
Fields of the SOM	Arithmetic mean $\bar{x}$	Standard deviation s	Coefficient of variation $cv\%$	Arithmetic mean $\bar{x}$	Standard deviation s	Coefficient of variation $cv\%$
1 Study attitude	67.73	25.42	37.53	60.88	25.09	41.21
2 Mathematics confidence	44.96	26.63	59.23	59.11	28.23	47.76
3 Study habits	56.96	26.51	46.54	57.53	28.69	49.87
4 Problem solving behaviour	63.96	27.27	42.64	68.26	28.71	42.06
5 Study environment	46.13	21.29	46.15	51.80	26.17	50.52
6 Information processing	70.60	20.35	28.78	70.38	23.41	33.26

Table 6-8 The arithmetic mean, standard deviation and coefficient of variation regarding the SOM/SOMT for the 2001 POSC group

	2001 POSC					
	SOM (Pre-intervention) (N=38)			SOMT-1 (Post-intervention) (N=36)		
Fields of the SOM	Arithmetic mean $\bar{x}$	Standard deviation s	Coefficient of variation $cv\%$	Arithmetic mean $\bar{x}$	Standard deviation s	Coefficient of variation $cv\%$
1 Study attitude	68.00	23.70	34.85	73.66	23.50	31.90
2 Mathematics confidence	51.15	22.74	44.46	58.33	23.25	39.86
3 Study habits	59.15	27.94	47.24	64.33	28.23	43.88
4 Problem solving behaviour	65.84	29.70	45.11	71.30	28.12	39.44
5 Study environment	59.18	21.33	36.04	59.33	23.65	39.86
6 Information processing	69.73	24.49	35.12	67.83	19.77	29.15

Table 6-9 The arithmetic mean, standard deviation and coefficient of variation regarding the SOMT for the 2002 POSC group

	2002 POSC					
	SOMT-2 (Pre-intervention) (N=50)			SOMT-3 (Post-intervention) (N=46)		
Fields of the SOM	Arithmetic mean $\bar{x}$	Standard deviation s	Coefficient of variation $cv\%$	Arithmetic mean $\bar{x}$	Standard deviation s	Coefficient of variation $cv\%$
1 Study attitude	76.35	18.11	23.72	78.21	18.59	23.77
2 Mathematics confidence	50.92	25.42	49.92	61.16	23.09	37.75
3 Study habits	72.21	23.61	32.70	76.60	19.79	25.84
4 Problem solving behaviour	78.80	20.78	26.37	82.45	18.57	22.52
5 Study environment	54.86	25.89	47.19	62.43	27.10	43.41
6 Information processing	73.89	22.05	29.84	78.97	19.57	24.78

With regard to the questionnaire as a pre-intervention instrument, the coefficient of variation has the smallest value in field six (Information processing) for the 2000 POSC group and in field one (Study attitude) for the 2001 and 2002 POSC groups. It can be deduced that in these cases the values in the mentioned fields are reasonably dense around the arithmetic mean.

With regard to the questionnaire as a pre-intervention instrument, the coefficient of variation has the largest value in field two (Mathematics confidence) for the 2000 and 2002 POSC groups and in field three (Study habits) for the 2001 POSC group. In these cases, relative large values occur in the fields Mathematics confidence and Study habits for all three groups indicating that the values are less dense around the arithmetic mean and more spread out.

With regard to the questionnaire as a post-intervention instrument, the coefficient of variation has the smallest relative value in field six (Information processing) for the 2000 and the 2001 POSC groups and in field four (Problem solving behaviour) for the 2002 POSC group. It is noticeable that the coefficient of variation has the second smallest value in field one (Study attitude) for all three groups indicating that for all three the groups the values in the field Study attitude are reasonably dense around the arithmetic mean.

With regard to the questionnaire as a post-intervention instrument, the coefficient of variation has the largest relative value in field three (Study habits) for the 2001 POSC group and in field five (Study environment) for the 2000 and 2002 POSC groups. It is noticeable that for the 2001 POSC group the value of the coefficient of variation is also relative large in the field Study environment. It thus follows that the values are statistically not dense with regard to the arithmetic mean and spread out for all the groups.

6.2.1 Inferential statistics

6.2.1.1 Predictive validity: Regression analysis

Concerning the use of the SOM (used as pre-intervention instrument[110]) as a predictor for performance in mathematics, the following statistical hypothesis is considered:

Hypothesis H1-1:

$H_0$1-1: The scores in the different fields of the SOM cannot be regarded as predictors of students' marks in mathematics.

H_A1-1: The scores in the different fields of the SOM can be regarded as significant predictors of students' marks in mathematics.

In Table 6-10 the results of step-wise regression analysis with the six fields of the SOM as independent variables and the performance in mathematics as dependent variable are given for the 2000 and 2001 POSC groups.

[110] Used with the 2000 and 2001 POSC groups.

Table 6-10 Step-wise regression model of the SOM and mathematics performance for the POSC 2000 and POSC 2001 groups

Fields of the SOM	Parameter estimate	Partial coefficient of determination R^2	Model/Cumulative coefficient of determination R^2	*P*
POSC 2000 group (N=30):				
Information processing (IP)	0.2528	0.3918	0.3918	0.0002*
Problem-solving behaviour (PSB)	0.1428	0.0772	0.4689	0.0579
Regression equation:	$y_1 = 34.44 + 0.25$ IP + 0.14 PSB			
POSC 2001 group (N=38):				
Mathematics confidence (MC)	0.2397	0.2515	0.2515	0.0013*
Regression equation:	$y_2 = 45.65 + 0.25$ MC			

* Significant at the 5% level

The data in Table 6-10 indicate that the fields Information processing (IP) and Mathematics confidence (MC) of the SOM are significant predictors (at a 5% level) for performance in mathematics. The field Problem solving behaviour (PSB) has a marginal contribution as predictor for performance in mathematics.

Regarding sub-hypothesis H1-1, it follows from Table 6-10 that three of the fields of the SOM, although not simultaneously, can be regarded as significant predictors of performance in mathematics and in these cases hypothesis $H_0 1$-1 can be rejected in favour of hypothesis $H_A 1$-1.

Concerning the use of the SOMT (used as pre-intervention instrument) as a predictor for performance in a standard first semester course in calculus, the following statistical hypothesis is considered:

Hypothesis H1-2:

$H_0$1-2: The scores in the different fields of the SOMT can not be regarded as predictors of students' marks in mathematics.

H_A1-2: The scores in the different fields of the SOMT can be regarded as significant predictors of students' marks in mathematics.

In Table 6-11 the results of step-wise regression analysis with the different fields of the SOMT-2 as independent variables and the performance in mathematics as the dependent variable are given for the 2002 POSC group.

Table 6-11 Step-wise regression model of the SOMT-2 and mathematics performance for the 2002 POSC group (N=50)

Fields of the SOMT	Parameter estimate	Partial coefficient of determination R^2	Model/Cumulative coefficient of determination R^2	*P*
Study environment (SE)	0.2256	0.1203	0.1203	0.0146*
Information Processing (IP)	-0.1540	0.0605	0.1809	0.0717
Regression equation:	$y_5 = 63.14 + 0.23$ SE $- 0.15$ IP			

* Significant at the 5% level

The data in Table 6-11 indicates that the field Study Environment (SE) is a significant predictor (on a 5% level) for performance in mathematics. In this case hypothesis $H_0$1-2 can be rejected in favour of hypothesis H_A1-2.

The field Information processing (IP) has a marginal but negative contribution as predictor for performance in mathematics. From the available data it is not clear how this negative value should be interpreted. For the 2002 POSC group the correlation[111] between Information Processing and the final mark in the first semester calculus course is poor and not statistically significant. Feedback from the 2002 POSC group on possible reasons[112] for

[111] See Table 6-15 on page 262.
[112] See Table 6-28 on page 279 and Table 6-29 on page 280.

not statistically significant. Feedback from the 2002 POSC group on possible reasons[112] for deterioration/improvement regarding Information processing on study orientation only indicate that these students did not consider this aspect as having a notable influence on their study orientation.

The regression equations that can be used to predict the performance for mathematics in a standard first semester course in calculus are summarised in Table 6-12.

Table 6-12 Regression equations regarding the SOM and SOMT

Instrument	Group	Regression equation: Predictor for mathematics performance
SOM	2000 POSC	$y_1 = 34.44 + 0.25\ \text{IP} + 0.14\ \text{PSB}$
	2001 POSC	$y_2 = 45.65 + 0.25\ \text{MC}$
SOMT-2	2002 POSC	$y_3 = 63.14 + 0.23\ \text{SE} - 0.15\ \text{IP}$

6.2.1.2 Simultaneous validity: Pearson correlation

Pearson correlations between the different fields of the SOMT (used as a post-intervention instrument) and performance in a standard first semester course in calculus are considered. The following arbitrary criterion for the correlation coefficient is accepted for the purposes of this study, namely:

The correlation is good if $|r| > 0.75$; it is acceptable if $-0.75 \leq r < -0.25$ or $0.25 < r \leq 0.75$ and it is poor if $-0.25 \leq r \leq 0.25$.

In Table 6-13, Table 6-14 and Table 6-15 the Pearson correlations between the fields of the SOMT (used as a post-intervention instrument) as independent variables and performance in the standard first semester course in calculus as dependent variable are given for the 2000, 2001 and 2002 POSC groups respectively.

The following research hypothesis regarding the correlation between the different fields of the SOMT and performance in mathematics is investigated, namely that:

[112] See Table 6-28 on page 279 and Table 6-29 on page 280.

Significant correlations occur between the different fields of the SOMT and performance in the standard first semester course in calculus.

From the results in Table 6-14 it follows that for the 2001 POSC group the correlations between mathematics performance and Study attitude (field one), mathematics performance and Problem solving behaviour (field four) and mathematics performance and Study environment (field five) are acceptable. Of these the correlations between mathematics performance and Study attitude (field one) and between mathematics performance and Study environment (field five) are statistically significant at a 5% level.

According to the results in Table 6-15 the correlations between mathematics performance and all the fields of the SOMT are poor for the 2002 POSC group.

Post hoc analysis was carried out to further investigate the results in Table 6-15. This was done by comparing the arithmetic means and standard deviations of the marks in the standard first semester course in calculus. In Table 6-16, Table 6-17 and Table 6-18 the arithmetic means and standard deviations are given with regard to the semester mark, exam mark and final mark of the first semester course in calculus. The data reflects the performance of the POSC students, the other 5YSP students and the 4YSP students in 2000, 2001 and 2002. The data is given for all the freshmen engineering students who wrote the final exam in the standard first semester calculus course during 2000-2002.

Using the arbitrary criterion for the correlation coefficient accepted for this study[113], it follows from Table 6-13 that the correlations between performance in mathematics and all the respective fields of the SOMT-1 are acceptable for the 2000 POSC group. All the correlations except between mathematics performance and Study environment (field five) are statistically significant at the 5% level.

[113] The correlation is good if $|r| > 0.75$; it is acceptable if $-0.75 \le r < -0.25$ or $0.25 < r \le 0.75$ and it is poor if $-0.25 \le r \le 0.25$.

Table 6-13 Pearson correlations between the fields of the SOMT-1 (post-intervention) and mathematics performance for the 2000 POSC group (N=26)

	Mathematics performance	
Fields of the SOMT	**Pearson correlation coefficient**	***P***
1 Study attitude (SA)	0.524	0.0060*
2 Mathematics confidence (MC)	0.460	0.0180*
3 Study habits (SH)	0.431	0.0279*
4 Problem solving behaviour (PSB)	0.651	0.0003*
5 Study environment (SE)	0.373	0.0601
6 Information processing (IP)	0.611	0.0009*

* Significant at the 5% level

Table 6-14 Pearson correlations between the fields of the SOMT-1 (post-intervention) and mathematics performance for the 2001 POSC group (N=35)

	Mathematics performance	
Fields of the SOMT	**Pearson correlation coefficient**	***P***
1 Study attitude (SA)	0.481	0.0034*
2 Mathematics confidence (MC)	0.198	0.2531
3 Study habits (SH)	0.190	0.2724
4 Problem solving behaviour (PSB)	0.296	0.0832
5 Study environment (SE)	0.443	0.0077*
6 Information processing (IP)	0.231	0.1799

* Significant at the 5% level

Table 6-15 Pearson correlations between the fields of the SOMT-3 (post-intervention) and mathematics performance for the 2002 POSC group (N=46)

	Mathematics performance	
Fields of the SOMT	**Pearson correlation coefficient**	***P***
1 Study attitude (SA)	0.072	0.6307
2 Mathematics confidence (MC)	0.022	0.8814
3 Study habits (SH)	0.240	0.1068
4 Problem solving behaviour (PSB)	0.218	0.0143*
5 Study environment (SE)	0.190	0.2040
6 Information processing (IP)	0.163	0.2777

* Significant at the 5% level

Table 6-16 Arithmetic means and standard deviations for marks in the standard first semester course in calculus 2000 for the POSC, other 5YSP and 4YSP groups

		Semester mark		Exam mark		Final mark	
Group	N	Arithmic mean $\bar{x}$	Standard deviation s	Arithmic mean $\bar{x}$	Standard deviation s	Arithmic mean $\bar{x}$	Standard deviation s
POSC	33	61.00	10.84	57.09	17.59	59.52	13.90
Other 5YSP	62	54.50	10.74	45.79	19.17	50.55	14.07
4YSP	406	66.24	13.85	60.70	19.48	63.77	15.75

Table 6-17 Arithmetic means and standard deviations for marks in the standard first semester course in calculus 2001 for the POSC, other 5YSP and 4YSP groups

		Semester mark		Exam mark		Final mark	
Group	N	Arithmic mean $\bar{x}$	Standard deviation s	Arithmic mean $\bar{x}$	Standard deviation s	Arithmic mean $\bar{x}$	Standard deviation s
POSC	40	58.83	12.03	58.70	12.84	59.10	11.08
Other 5YSP	46	52.35	11.76	35.22	15.99	45.65	12.26
4YSP	431	62.27	14.54	51.02	20.75	57.89	15.99

Table 6-18 Arithmetic means and standard deviations for marks in the standard first semester course in calculus 2002 for the POSC, other 5YSP and 4YSP groups

		Semester mark		Exam mark		Final mark	
Group	N	Arithmic mean $\bar{x}$	Standard deviation s	Arithmic mean $\bar{x}$	Standard deviation s	Arithmic mean $\bar{x}$	Standard deviation s
POSC	51	56.37	14.00	74.63	16.52	63.76	14.30
Other 5YSP	41	51.49	9.92	56.85	13.71	53.76	9.84
4YSP	547	59.02	13.15	66.76	16.35	62.16	13.65

Inspection of the data in Table 6-16, Table 6-17 and Table 6-18 reveals the following tendency that may account for the lack of correlation found between mathematics performance and the fields of the SOMT for the 2002 POSC group. In 2000 and 2001 the average semester marks are higher than the exam marks for all the groups. The corresponding standard deviations are relatively similar for all three of the groups except in 2001 where the standard deviation of the 4YSP is higher than those of the other two groups. In contrast with this tendency, the average semester mark is less than the exam mark in 2002 for all three the groups. In the latter case, the difference between the exam mark and the semester mark is the greatest for the POSC group (18.26%) followed by the 4YSP group (7.74%) and the other 5YSP group (5.36%). The standard deviations for the POSC group as well as the 5YSP group regarding both the semester mark and the exam mark in 2002 are relatively similar and both differ from that of the other 5YSP group in 2002. These figures point to the fact that in 2002 the POSC group seemingly performed remarkably well in the standard mathematics course in comparison with the other first year engineering students.

6.3 Academic performance in mathematics

Concerning the possible effect of the support in the POSC on performance in mathematics, the following research hypothesis is considered:

> The average mark achieved by the POSC group in a standard first semester calculus course is higher than the average mark of students not enrolled for the POSC.

From the data in Table 6-16, Table 6-17 and Table 6-18 on page 263 it is clear that the average final mark[114] in the standard first semester course in calculus of the POSC students is higher that that of the other 5YSP students in 2000, 2001 and 2002. The average mark of the POSC students is also marginally higher than that of the 4YSP students in 2001 and in 2002.

[114] In 2000 the final mark for mathematics in the standard first semester calculus course was calculated as semester mark 50% + exam mark 50%. In 2001 and 2002 the final mark was calculated as semester mark 60% + exam mark 40%.

6.4 Comparing means (post minus pre) of pre- and post-intervention scores on the SOM/SOMT

The non-parametric Wilcoxon rank-sum Test (BMDP3D, 1993) was used to compare (for each field) the difference between the Study Orientation Questionnaire in Mathematics at course beginning and at course end. The following statistical hypothesis is investigated:

Hypothesis H2:

$H_0$2: No significant differences exist in the arithmetic means of the fields of the Study Orientation Questionnaire in Mathematics at the beginning of the POSC and at the end of the POSC.

H_A2: Significant differences exist in the arithmetic means of the fields of the Study Orientation Questionnaire in Mathematics at the beginning of the POSC and at the end of the POSC.

In Table 6-19 the means, standard deviations, Wilcoxon statistics and *p*-values for the individual fields regarding the differences between the Study Orientation Questionnaire in Mathematics at course beginning and at course end are given.

From the data in Table 6-19 it follows that for the 2000 POSC group there was significant improvement in Mathematics confidence and Problem solving behaviour. The 2001 POSC group improved in Study attitude, Mathematics confidence, Study habits and Problem solving behaviour. The 2002 POSC group showed significant improvement in Mathematics confidence, Study habits and Information processing and to a lesser degree also in Problem solving behaviour.

Regarding hypothesis H2, it follows from Table 6-19 that with regard to the field Mathematic confidence, there are significant differences in the arithmetic mean between the pre and post-questionnaires in study orientation towards mathematics for all the groups and in this case hypothesis $H_0$2 can be rejected in favour of hypothesis H_A2. For the 2001 POSC group, hypothesis $H_0$2 can be rejected in favour of hypothesis H_A2 with regard to the fields Study attitude, Study habits and Problem solving behaviour. For the 2002 POSC hypothesis $H_0 2$ can also be rejected in favour of hypothesis $H_A 2$ with regard to Study habits and Information processing. However, with regard to the field Study environment, hypothesis $H_0 2$ is retained for all the groups.

Table 6-19 Means, standard deviations, test statistics and *p*-values of the difference between the study orientation questionnaire at course end and at course beginning for the individual fields of the SOM/SOMT

	2000 POSC				2001 POSC				2002 POSC			
	N=26				N=35				N=46			
Fields of the SOM/SOMT	**Mean**	**Standard deviation**	**Wilcoxon test statistic**	***P***	**Mean**	**Standard deviation**	**Wilcoxon test statistic**	***P***	**Mean**	**Standard deviation**	**Wilcoxon test statistic**	***P***
1 Study attitude	-4.53	18.76	119.0	0.3756	7.11	15.52	149.0	0.0111*	2.85	18.49	411.0	0.4537
2 Mathematics confidence	14.00	27.29	44.0	0.0074*	6.65	19.95	171.0	0.0503*	8.73	28.25	286.5	0.0149*
3 Study habits	3.11	23.28	145.5	0.6471	8.88	17.80	134.0	0.0088*	5.83	19.60	356.0	0.0438*
4 Problem solving behaviour	6.96	17.84	87.5	0.0741	8.85	16.17	110.5	0.0070*	4.84	18.06	322.5	0.1065
5 Study environment	4.76	19.18	117.5	0.2255	2.77	19.53	244.5	0.3638	6.00	26.39	409.0	0.1505
6 Information processing	1.23	18.58	137.5	0.5008	-1.31	21.88	250.0	0.4164	5.96	20.43	288.5	0.0415*

* Significant at the 5% level

6.5 Comparing groups regarding differences in means of pre- and post-intervention scores on the SOM/SOMT

One way analysis of variance (ANOVA) was used to investigate the differences (post minus pre) in the arithmetic means of the fields of the Study Orientation Questionnaire in Mathematics used as pre- and post-intervention instruments between the 2000, the 2001 and the 2002 POSC groups. Where significant differences existed, the multiple Least Square Means *post hoc* procedure was applied to determine the specific group differences. The following statistical hypothesis is investigated:

Hypothesis H3:

$H_0 3$: No significant differences (post minus pre) exist in the means of the 2000, 2001 and 2002 POSC groups for the fields of the Study Orientation Questionnaire in Mathematics.

$H_A 3$: Significant differences (post minus pre) exist in the means of the 2000, 2001 and 2002 POSC groups for the fields of the Study Orientation Questionnaire in Mathematics.

In Table 6-20 the results are given of ANOVA comparing the differences in arithmetic means of the fields of the Study Orientation Questionnaire in Mathematics as pre- and post-intervention instruments for the 2000, 2001 and 2002 POSC groups.

Regarding hypothesis H3, it follows from Table 6-20 that statistically significant differences (post minus pre) exist in the means of the 2000, 2001 and 2002 POSC groups for the field Study attitude. In this case hypothesis $H_0 3$ can be rejected in favour of hypothesis $H_A 3$.

However, with regard to all the other fields, there are no significant differences (post minus pre) in the means of the 2000, 2001 and 2002 POSC groups. In these cases hypothesis $H_0 3$ is retained.

Table 6-20 Results of ANOVA comparing the difference between the arithmetic means of the fields of the Study Orientation Questionnaire as pre- and post-intervention instruments for the 2000, 2001 and 2002 POSC groups

		POSC groups per year N=107				
Field	**Post minus Pre**	**2000**	**2001**	**2002**	**F**	***P***
1 Study attitude	Pre	67.73	68.00	76.35		
	Post	60.88	73.66	78.21		
	Post-Pre	-6.85[a]	+5.66[b]	+1.86[b]	3.27	0.0418*
2 Mathematics confidence	Pre	44.96	51.15	50.92		
	Post	59.11	58.33	61.19		
	Post-Pre	+14.5	+7.18	+10.27	0.64	0.5313
3 Study habits	Pre	56.96	59.15	72.21		
	Post	57.53	64.33	76.60		
	Post-Pre	+0.57	+5.18	+4.39	0.63	0.5337
4 Problem solving behaviour	Pre	63.96	65.84	78.80		
	Post	68.26	71.30	82.45		
	Post-Pre	+4.3	+5.46	+3.65	0.53	0.5894
5 Study environment	Pre	46.13	59.18	54.86		
	Post	51.80	59.33	62.43		
	Post-Pre	+5.67	+0.15	+7.57	0.20	0.8176
6 Information processing	Pre	70.60	69.73	73.89		
	Post	70.38	67.83	78.97		
	Post-Pre	-0.22	-1.9	+5.08	1.36	0.2735

* Significant at the 5% level
[a,b] Means with different superscripts within rows differ significantly at $p < .05$

The *post hoc* results indicate that the means in the field Study attitude differ statistically significantly between the 2000 and 2001 POSC groups and between the 2000 and 2002 POSC groups. No statistically significant difference between the means for the 2001 and 2002 POSC groups occurred.

A possible reason for the differences between the 2000 POSC groups and the other two groups in Study attitude may be attributed to the fact that the 2000 POSC group did the post-intervention questionnaire at a later stage (in the second semester of the second year) that the other two groups. The 2001 and 2002 POSC groups did the post-intervention questionnaire in the second semester of their first year. For all three groups the proposed learning facilitation strategy in the mathematics component of the POSC was followed in the first semester of the first year. Other factors (experienced in the second study year) may thus particularly have influenced the 2000 POSC group's Study orientation.

6.6 Results: Herrmann Brain Dominance Instrument (HBDI)

In this section the average Herrmann Brain Dominance (HBD) profiles as well as the distribution of thinking style preferences are discussed. The subjects include the 2000 POSC students, the 2000 group of first year civil engineering students and the 1999 group of science students. Data pertaining to the HBDI was processed through the HBDI Processing System Version 5.2 (Herrmann International, 1999b).[115] The results were statistically analysed using the Kruskal-Wallis test (BMDP3D, 1993) to determine the distribution of the thinking style preferences of first year engineering students on a support course. The latter analysis is addressed in two ways, namely a comparison between two groups of freshmen engineering students and a comparison between two groups of students both on support courses (the one in the Faculty of Engineering and the other in the Faculty of Natural Sciences). In the first case the results pertaining to the POSC students are compared to those of a group of first year civil engineering students and in the second case they are compared to those of a group of science students on a support course.

6.2.1 Distribution of thinking style preferences

6.6.1.1 Average profiles

In Table 6-21 the average scores per quadrant according to the HBDI for the POSC, civil engineering and science students are given. In Figure 6-1 the average HBD profiles (generated by the HBDI Processing System) of the POSC, civil engineering and science students are given. All the profiles in Figure 6-1 tend towards a profile displaying almost equal preferences in all four quadrants of the Herrmann whole brain model. Inspection of Table 6-21 reveals the following regarding the average values per quadrant. The two groups of engineering students have a higher average value in quadrants A and B than the science group. In quadrants B and C the average score for the science groups is higher than that of the two engineering groups.

[115] See Chapter 4 section 4.6.6 for information on the scoring of the HBDI.

Table 6-21 Average scores per quadrant according to the HBDI for the POSC, civil engineering and science students

	A	B	C	D
2000 POSC 2000 students	82	70	65	74
Civil engineering students	84	76	55	76
Science students	70	84	71	63

Figure 6-1 Average profiles for the 2000 POSC, civil engineering and science students according to the HBDI

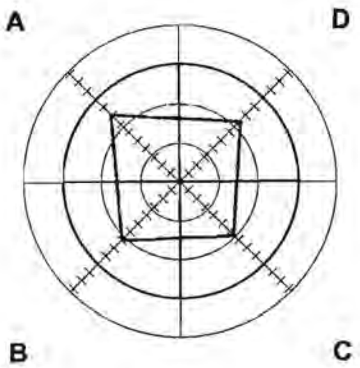

Figure 6-1 A
2000 POSC students

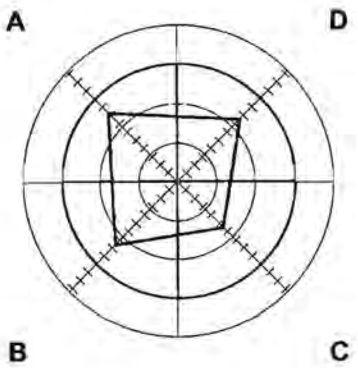

Figure 6-1 B
Civil engineering students

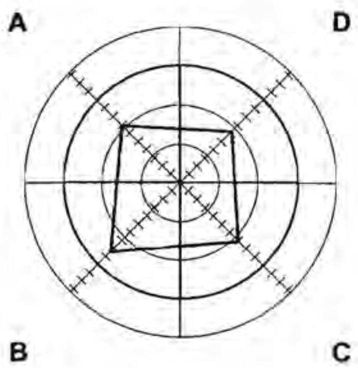

Figure 6-1 C
Science students

6.6.1.2 Dominance in the distribution of profiles

The differences in preferences for the four quadrants of the Herrmann whole brain model are also noticeable in the number of students with thinking preferences per quadrants. In Table 6-22 the number of POSC, civil engineering and science students per quadrant is given indicating their thinking preferences for the specific quadrant. Two students in the POSC group have HBD profiles representing thinking preferences almost equally distributed across all for quadrants and scores of the same magnitude for all the quadrant.

Table 6-22 Number of POSC, civil engineering and science students with highest score for thinking preferences per quadrant

	A	B	C	D	A B C D
2000 POSC students	15	5	5	6	2
Civil engineering students	18	3	6	3	0
Science students	9	18	7	4	0

In Figure 6-2 the dominance in distribution of the individual HBD profiles of the three groups of students is given. The distribution of profiles confirm the analysis in section 6.6.1.1 regarding the linear hemisphere that the thinking style preference of first year engineering students are seemingly more towards the upper left quadrant whereas the thinking preferences of this group of first year science students are more towards the lower left quadrant of the Herrmann whole brain model. Furthermore, the individual profiles of the two groups of engineering students seem to cluster in the upper left and right quadrants (A and D) of the Herrmann whole brain model whereas the profiles of the science students seem to cluster in the lower left and right quadrants (B and C) of the Herrmann whole brain model.

Figure 6-2 Distribution of HBD profiles for the 2000 POSC, civil engineering and science students

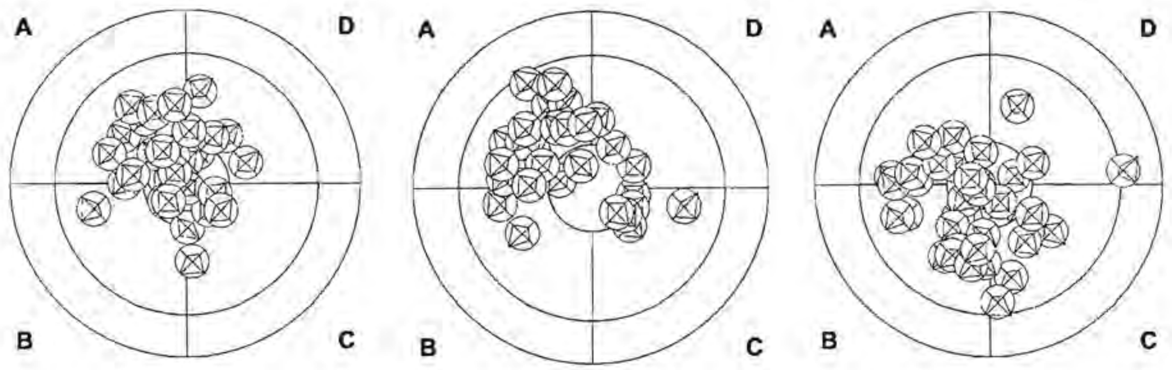

Figure 6-2 A
2000 POSC students

Figure 6-2 B
Civil engineering students

Figure 6-2 C
Science students

6.6.2 Comparing groups within quadrants of the HBDI

In this section the thinking style preferences of the POSC, civil engineering and science students are statistically analysed in order to determine the thinking style preferences of first year engineering students on a support course. The following statistical hypothesis regarding the scores for the different quadrants of the HBDI is investigated:

Hypothesis H4:

$H_0$4: No differences exist in the arithmetic means of the scores for the different quadrants of the HBDI between the POSC group, the civil engineering group and science students on a support course.

H_A4: Significant differences exist in the arithmetic means of the scores for the different quadrants of the HBDI between the POSC group, the civil engineering group and science students on a support course.

The non-parametric Kruskal-Wallis test (BMDP3D, 1993) was used to compare the arithmetic mean scores of the 2000 POSC, civil engineering and science groups for each of the four quadrants of the Herrmann whole brain model as measured by the HBDI. Table 6-23 on the following page gives the arithmetic means, standard deviations and *p*-values regarding the quadrants of the HBDI for the three groups.

From Table 6-23 it follows that there is no significant difference between the means of the scores for all the quadrants of the HBDI between the POSC group and the civil engineering group. Therefore, hypothesis $H_0$4 is retained and it is accepted that no differences exist in the arithmetic means of the scores for all four quadrants of the HBDI between the POSC group and the civil engineering group.

There is also no significant difference between the means of the scores for the B quadrant of the HBDI between all three the groups and in this case hypothesis $H_0$4 is retained and it is deduced that no differences exist in the arithmetic means of the scores for the B quadrant of the HBDI between all three groups.

From Table 6-23 it further follows that there is a significant difference between the means of the scores for the A-quadrant of the HBDI between the POSC group and the science group and between the civil engineering group and the science group respectively. Therefore hypothesis H_04 is be rejected in favour of the alternative hypothesis namely that there is a difference in the means of the scores for the A-quadrant of the HBDI between the POSC students and the science students and between the civil engineering group and the science group.

There is also a significant difference between the means of the scores for the C- and D-quadrants of the HBDI between the civil engineering group and the science group. In these cases hypothesis H_04 is rejected in favour of the alternative hypothesis namely that there is a difference in the means of the scores for the C and D quadrants of the HBDI between the civil engineering group and the science group. However, there is no significant difference between the means of the scores for the C and D quadrants of the HBDI between the POSC group and the science group and for these two groups the hypothesis H_04 is retained.

In all the cases where hypothesis H_04 is retained it may suggest that the sample data is be insufficient to indicate whether the means of the scores for the different quadrants of the HBDI differ or do not differ between the three groups of students.

Table 6-23 Means of the POSC, civil engineering and science groups for each of the quadrants of the HBDI

	POSC group (N=33)		Civil engineering group (N=30)		Science group (N=38)		
HBDI	**Arithmetic mean** $\bar{x}$	**Standard deviation** s	**Arithmetic mean** $\bar{x}$	**Standard deviation** s	**Arithmetic mean** $\bar{x}$	**Standard deviation** s	***P***
A-quadrant	82.06^{a}	16.89	83.66^{a}	20.70	69.78^{b}	18.70	0.0044*
B-quadrant	70.45^{ab}	13.59	76.03^{ab}	15.25	83.86^{b}	16.68	0.0006*
C-quadrant	64.75^{ab}	17.44	55.03^{a}	22.03	71.15^{b}	21.42	0.0045*
D-quadrant	73.06^{ab}	17.41	76.46^{a}	17.59	63.34^{b}	19.99	0.0085*

* Significant at the 5% level

^{a,b} Means with different superscripts within rows differ significantly at $p < .05$

6.7 Results: Lumsdaine and Lumsdaine Learning Activity Survey (LAS)

The main aim with the implementation of the LAS in 2000 was to determine if this questionnaire can be used in stead of the HBDI to make students aware of their own thinking style preferences.

The following research hypothesis regarding the quadrants of the HBDI and the corresponding sections of the LAS is investigated:

> Significant correlations exist between the scores in the quadrants of the HBDI and the scores in the corresponding sections of the LAS for the 2000 POSC group and the 2000 civil engineering group.

Pearson correlation was used to determine whether there are significant correlations between the quadrants of the HBDI and the corresponding sections of the LAS questionnaire. These correlations and the corresponding values for p are given in Table 6-24.

Table 6-24 Pearson correlations and P-values between the quadrants of the HBDI and corresponding sections of the LAS

	LAS			
HBDI	**Section A**	**Section B**	**Section C**	**Section D**
A-quadrant	r = 0.0825 p = 0.5307			
B-quadrant		r = 0.2149 p = 0.0991		
C-quadrant			r = 0.1588 p = 0.2254	
D-quadrant				r = 0.1956 p = 0.1341

From Table 6-24 it follows that $0.0991 \leq p \leq 0.5037$ in all cases. Therefore, no statistically significant correlation exists between any of the quadrants of the HBDI and the corresponding section of the LAS. The use of the LAS instead of the HBDI is thus not recommended.

6.8 Results: Felder Soloman Index of Learning Styles (ILS)

The results concerning the choices per category of the ILS are given in Table 6-25 for the 2001 POSC group and in Table 6-26 for the 2002 POSC group.

Qualitative analysis of the choices in Table 6-25 indicates that the number of choices between 'reflective' and 'active' as well as between 'sequential' and 'global' is almost evenly spread among the 2001 POSC group. The total number of choices for 'verbal' is much lower than for 'visual' and the number of choices for 'intuitive' is also less than for 'sensing'.

It is noticeable that although the number of choices for 'visual' and for 'sensing' is high these choices reflect mild to moderate preferences. Furthermore, none of choices in any of the categories reflects high figures for strong preferences in the particular category.

Table 6-25 Number of choices per category of the ILS according to mild, moderate or strong preferences for the 2001 POSC group (N=35)

Mild	Moderate	Strong	Mild	Moderate	Strong
Reflective			Active		
10	5	2	12	4	2
Reflective total		17	18		Active total
Verbal			Visual		
2	5	0	11	12	5
Verbal total		7	28		Visual total
Sensing			Intuitive		
20	3	1	7	3	1
Sensing total		24	11		Intuitive total
Sequential			Global		
9	6	3	14	2	1
Sequential total		18	17		Global total

Qualitative analysis of the choices in Table 6-26 indicates that the number of choices between 'reflective' and 'active' as well as between 'sequential' and 'global' is almost evenly spread for the 2002 POSC group. The total number of choices for 'verbal' is much lower than for 'visual' and the number of choices for 'intuitive' is also less than for 'sensing'. Although the number of choices for 'visual' and for 'sensing' is high these choices reflect mild to moderate preferences. Furthermore, none of choices in any of the categories reflects high figures for strong preferences in the particular category.

Table 6-26 Number of choices per category of the ILS according to mild, moderate or strong preferences for the 2002 POSC group (N=51)

Mild	Moderate	Strong	Mild	Moderate	Strong
Reflective			**Active**		
19	7	3	13	9	0
Reflective total		**29**	**22**		**Active total**
Verbal			**Visual**		
3	0	0	20	19	9
Verbal total		**3**	**48**		**Visual total**
Sensing			**Intuitive**		
20	11	0	15	5	0
Sensing total		**31**	**20**		**Intuitive total**
Sequential			**Global**		
18	8	1	19	5	0
Sequential total		**27**	**24**		**Global total**

In Table 6-27 the distribution (as percentages) of choices for the categories of the ILS for the 2001 and 2002 POSC groups is given. It is noticeable that in the three categories verbal/visual, sensing/intuitive and sequential/global, the trend in preferences for the 2001 and 2002 groups is similar. Both groups have a much greater preference for visual than for verbal. About two thirds of each group prefer sensing to intuitive. Regarding the category sequential/global, the preferences are almost equally distributed for each of the categories sequential and global.

Table 6-27 Distribution of choices for the categories of the ILS for the 2001 and 2002 POSC groups

	Reflective	Active	Verbal	Visual	Sensing	Intuitive	Sequential	Global
2001 N=35	49%	51%	20%	80%	69%	31%	51%	49%
2002 N=51	57%	43%	6%	94%	61%	39%	53%	47%

6.9 Participant observation: participant feedback

For the purpose of the research as presented in this thesis the feedback from POSC participants during 2000-2001 is only qualitatively reported and discussed.

In Table 6-28 on page 279 possible reasons for a deterioration in study orientation in mathematics are given. The reasons are categorised according to feedback that students gave to explain their own weakening (if it occurred) in the different aspects of study orientation by comparing their study orientation (profile) at the beginning of the POSC to their study orientation (profile) after the POSC.

In Table 6-29 on page 280 possible reasons for improvement in study orientation in mathematics are given. The reasons are categorised according to feedback that students gave to explain their own improvement in the different aspects of study orientation by comparing their study orientation (profile) at the beginning of the POSC to their study orientation (profile) after the POSC. It should be kept in mind that study orientation in mathematics for the purposes of the research reported in this thesis reflects the students' study orientation toward the standard mathematics course and not towards the mathematics component of the POSC.

It should also be mentioned that the data in Table 6-28 and Table 6-29 are not ordered in any way and that the frequency of similar answers were not taken into account.

Students' own perceptions of the extent to which the study orientation profile, as measured by the SOMT, reflects study orientation towards mathematics were noted by the researcher during interviews and was also given through a writing assignment.[116] Most of the students agreed that the profile (regarding all six aspects of the questionnaire) was a fair indication of their orientation towards mathematics. Some students felt that it was a precise reflection of their orientation. Some students felt that certain aspects of the profile were a fair indication of their orientation and disagreed regarding some other aspects. With regard to those aspects that they did not consider a true reflection of their study orientation, they indicated that they perceived their orientation to be better than indicated by the profile. It was noticeable that with regard to those aspects of the SOMT profile where a favourable study orientation was not displayed, all students remarked that they intend working on that aspect to improve in it.

Table 6-28 Possible reasons for deterioration in study orientation

Aspect of study orientation	Factors that have a negative effect on study orientation
Study attitude (SA)	When the meaningfulness/usefulness of the work is not clear. Not being serious enough about studying. Negative peer influence. Feeling of hopelessness from not doing well (in other subjects).
Mathematics confidence (MC)	Bad grades. Not enough time on task. Trying hard but not achieving good grades. Too great a volume of work.
Study habits (SH)	Influence of lecturer – if he/she does not encourage students to work hard, they don't. Ignoring time planning.
Problem solving behaviour (PSB)	Lack of interest.
Study environment (SE)	New and foreign environment in a hostel. Too busy social life.
Information processing (IP)[117]	

[116] See Appendix G for a copy of the writing assignment.
[117] Students did not mention any aspect that has a negative influence on orientation with regard to this field.

Table 6-29 Possible reasons for improvement in study orientation

Aspect of study orientation	Factors that contribute to improved study orientation
Study attitude (SA)	Peer influence. Working in a study group. Information in the POSC. Personal motivation to work harder to improve grades. Achieving better grades. Better understanding of the work leads to enjoying maths and a positive attitude. Believing in oneself.
Mathematics confidence (MC)	Skills acquired through the POSC. Studying in groups. Time on task. Work and study everyday. Go to class prepared. Better understanding of the work. Believing in oneself. Achieving good grades. Making sense from what one is doing.
Study habits (SH)	Peer influence. Working in a study group. Skills acquired through the POSC. Follow up on mistakes and understand what was wrong. Good time management. Focus on the method and not only on getting to the correct answer.
Problem solving behaviour (PSB)	More practice. Peer interaction and lecturer influence give insight into different and useful strategies. Skills acquired through the POSC. Create a visual picture to understand something. Trying different approaches.
Study environment (SE)	Scheduling residence activities, social activities and study time.
Information processing (IP)	Skills acquired through the POSC.

6.10 Summary

The results of the 2000-2002 study presented in this chapter can be summarised as follows.

The results obtained from item analyses, the Cronbach alpha coefficients and feedback from the students indicate that the Study Orientation Questionnaire in Mathematics Tertiary (SOMT) can be used with first year engineering students on a support course to create an awareness of their own study orientation towards mathematics. Furthermore, results from regression analyses indicate that most of the fields of the SOMT, although not simultaneously, can be regarded as predictors of performance in mathematics. ANOVA and *post hoc* analysis indicate that there are no significant differences in the means (post minus pre) of the fields of the SOMT between the 2000, 2001 and 2002 POSC groups except in the field Study habits.

Concerning the thinking style preferences of the POSC students, the results pertaining to the Herrmann Brain Dominance Instrument (HBDI) indicate that the thinking style preferences of first year engineering students on a support course represent an array of preferences distributed across all four quadrants of the Herrmann whole brain model. Furthermore, it seems as if the thinking style preferences of the POSC students (being first year engineering students on a support course) do not differ from those of first year civil engineering students, but do differ in some quadrants from those of first year science students on a support course. Qualitative analysis of the data obtained from the Felder Soloman Index of Learning Styles (ILS) endorses the fact that a group of students represents an array of learning preferences.

In the Chapter 7 the results are further discussed and conclusions and recommendation presented.