Chapter Five

Modelling Quantitative Measurements and Results

5.1 Introduction

This chapter explicates the final two stages in questionnaire development (§ 4.3.2) which include: (i) the quantitative analysis process of the data collected from 300 Mathematics teachers across eight EMDCs in the WCED, as well as (ii) the modelling of the quantitative measures and results (§ 5.2, 5.3, 5.4). During quantitative analysis the researcher analysed the data using SPSS™ (SPSS, 2012) and SAS™ (SAS Institute Inc, 2011). The analysis included descriptive (Addenda 5.1 and 5.2), inferential statistics (principal axis factor analysis with multiple variables from the questionnaire) (Addendum 5.3) and hierarchical linear modelling between extracted factors and the biographical information in Part A and B of the questionnaire where the dependency of answers from teachers in the same school is taken into account (Addendum 5.5). Descriptive statistics with frequencies and percentages represented the biographical information organised as frequencies and percentages (Cohen *et al.*, 2011:627; Neuman, 2011:387). Part G of the questionnaire (Addendum 4.11) was presented only as frequencies and percentages.

In order to validate the questionnaire, a principal axis factor analysis extracted individual items of the questionnaire into factors according to the correlation between items. KMO measure of sampling adequacy (Cohen *et al.*, 2011:641) indicated the measure of sample adequacy that ranged between 0 and 1 with a value of 0.5 as a suggested minimum. A measure of ≥0.9 indicated a good fit. The Barlett's test of sphericity (Cohen et al., 2011:641) determined if the covariance matrix was an identity matrix which would indicate that the variables were unrelated and unsuited for structure detention. Small values ($p \leq 0.05$) indicated that the factor analysis could be useful with the data. The pattern matrix of the principal axis factor analysis was interpreted for reliability of the data. A Cronbach Alpha tested the reliability of the extracted factors in Parts C, D, E, and F of the questionnaire. A Cronbach Alpha of 0.7 was considered acceptable for this factor analysis (Cohen *et al.*, 2011:639-640; McMillan & Schumacher, 2001:247) even though in many cases a smaller value would have sufficed.

Hierarchical linear models were used to determine whether there were significant differences between the biographical variables in Part A and Part B of the questionnaire (Addendum 4.11) and the factors from Governance (Responsibility of DBE, Policy initiatives, Responsibility of management, Responsibility to teaching and learning), School Environment (TK and TPACK), ICT (Contributors to SPD, ICT and SPD), and PD (Building a SPI, PD models and frameworks, PD strategies) by means of linear modelling. Two sets of hierarchical linear models were used: (i) hierarchical linear modelling in SPSS to test for differences in means, and (ii) Proc SURVEYREG in SAS to test for associations between ordered variables (SAS Institute Inc, 2011). The effect sizes for the differences in means were measured by a Cohen's d-values with guidelines for interpretation as follows: $d \leq 0.4$ as small with little or no significant difference, $0.5 \leq 0.8$ medium that tended towards practically significant difference and $d \geq 0.8$ large with practically significant difference. Only medium and large effect sizes and the $p \leq 0.05$ were used for this interpretation (Cohen, 1988:25-27). The effect sizes for the association between variables were measured by the proportion of variance explained R^2 by the model. (Cohen *et al.*, 2011:701; Field, 2013:276). The R^2 guidelines for interpretation related to: 0.01=a poor fit; 0.1=a moderate fit; and 0.25=a strong fit (Cohen *et al.*, 2011:662; Field, 2013).

5.2 Biographical Information

Part A and Part B of the questionnaire (Addendum 4.11) included items which related to personal and demographical information of the Mathematics teachers in the senior phase (Addenda 5.1 and 5.2).

Visual representation of the data during descriptive statistics is of the utmost importance (Neuman, 2011:386). The researcher selected the most appropriate method to display the findings which were a combination of various frequencies, percentages and tables (Cohen *et al.*, 2011:622). Some of the descriptive statistics of the questionnaire (items A1, A2, A5, and A6) were included in Chapter Four (§ 4.5.6) to describe and explain the population and sample selection of the study.

Table 5.1 provides the descriptive statistics of all the items in Part A and Part B of the questionnaire. Frequencies and percentages are used to explicate the data from Part A and Part B of the questionnaire. Items B2 and B3 are not included in the descriptive statistics as these contained confidential information. The percentage values were rounded off to the nearest whole number and represented accordingly in Table 5.1.

Table 5.1 Frequencies and Percentages of Part A and Part B of the Questionnaire

Items				Frequencies	Percentages
A1	Gender		Male	135	45
			Female	165	55
A2	Age		20-29	66	22
			30-39	71	24
			40-49	95	35
			50-59	57	29
			60+	11	4
A3	Total number of years teaching		0-9 years	113	38
			10-19 years	78	26
			20-29 years	77	26
			30-39 years	28	9
			40+	4	1
A4	Total number of years teaching Mathematics	Grade 7	0	230	77
			1-9 years	43	14
			10-19 years	14	5
			20-40	13	4
		Grade 8	0	73	24
			1-9 years	137	46
			10-19 years	41	14
			20-40	49	16

Items					Frequencies	Percentages
		Grade 9	0		50	17
			1-9 years		151	51
			10-19 years		42	14
			20-40		55	18
A5	Home language		English		58	19
			Afrikaans		188	63
			isiXhosa		54	18
A6	Language of Instruction		English		133	44
			Afrikaans		167	56
A7	Qualifications		DE III		21	7
			HDE/ACE		89	30
			BEd		45	15
			BA/BSC		70	23
			Post graduate		42	14
			Other		33	11
A8	Subject specialisation		Mathematics		252	84
			Other		48	16
B1	School districts		Metro Central		40	13
			Metro East		46	15
			Metro North		17	6
			Metro South		28	9
			Cape Winelands		68	23
			Eden Central Karoo		54	18
			Overberg		5	2
			West Coast		42	14
B4	School quintile		1		52	17
			2		21	7
			3		56	19
			4		61	20
			5		95	32
			Independent		15	5
B5	Type of school		Farm		15	5
			Semi-urban		107	36
			Urban		86	29
			Former Model C		76	25
			Independent		16	5
B6	Number of learners at school		0-500		53	18
			500-1000		117	39
			1000+		130	43
B10	Number of computer laboratories		0		15	5
			1		143	48
			2		88	29
			3		45	15
			4		8	3
			5		0	0
			6		1	0
B11	Computers at my school available for		Administration		286	95
			General teaching		242	81
			Mathematics Grade 7		40	13
			Mathematics Grade 8		139	46
			Mathematics Grade 9		159	53
B12	Computers with Internet available for		Administration	Yes	286	95
				No	14	5
	Computers with Internet available for		General teaching	Yes	214	71
				No	86	29
	Computers with Internet available for Mathematics teaching in		Grade 7	Yes	38	13
				No	262	87
			Grade 8	Yes	126	42
				No	174	58
			Grade 9	Yes	144	48
				No	156	52
B13	I rate my computer literacy level as		Poor		24	8
			Fair		73	24
			Good		153	51

Items				Frequencies	Percentages
		Excellent		51	17
B15	Personal computers available	School	Yes No	195 105	65 35
		Home	Yes No	258 42	86 14
B16	Internet access	School	Yes No	266 34	89 11
		Home	Yes No	195 105	65 35
B17	IWBs at school	Yes No		163 138	54 46
B18	Online course	Yes No		32 268	11 89

5.2.1 Gender

The two gender groups were well represented in the completion of the questionnaire. More females (55%) than males (45%) completed the questionnaire (Table 5.1). In the GET band in the WCED there was a suitable representation of both male and female teachers in Mathematics. This finding related to the male-female ratio of Mathematics teachers in the GET band in the WCED during 2009 of 69% female and 74% male (Western Cape Education Department, 2009).

5.2.2 Age

The data indicated a good balance in the variation of age. The majority of the participants (32%) of the Mathematics teachers were between 40-49 years old. The second largest group (22%) were between 30-39 years of age (Table 5.1) and nineteen per cent of the participants were reaching the retirement stage (50-59 years of age).

5.2.3 Years of Teaching Experience

The majority of the Mathematics teachers (38%) had between 0-9 years' experience teaching Mathematics in the GET band. An equal percentage (26%) of Mathematics teachers had between 10-19 years and 20-29 years of teaching experience. A small percentage (9%) and (1%) of the Mathematics teachers had extended teaching experience (30-39 and more years) (Table 5.1).

5.2.4 Years Teaching Mathematics

The majority of the Mathematics teachers taught for the maximum of nine years: fourteen percent of the Mathematics teachers taught grade 7 Mathematics, 46% taught grade 8, and 51% taught grade 9 (Table 5.1). Few of the Mathematics teachers taught Mathematics for more than twenty years.

5.2.5 Home Language

The majority of the Mathematics teachers (63%) spoke Afrikaans at home (Table 5.1). The Western Cape is a predominantly Afrikaans speaking province and 50% of the population in the Western Cape speak Afrikaans at home (Statistics South Africa, 2011). The second largest group of the Mathematics teachers spoke English as home language (19%), and 18% spoke isiXhosa at home (Table 5.1). English is the third most spoken language in the Western Cape with 20% of the inhabitants speaking English, and the second largest population (25%), speak isiXhosa (Statistics South Africa, 2011). The distribution and selection of the sample regarding home languages was suitable to the data collection process as it balanced well with the holistic provincial statistics.

5.2.6 Language of Instruction

Nationally in South Africa, language of instruction in schools is constantly under debate. However, the current education system in South Africa officially delivers education in only two (English and Afrikaans) of the eleven official languages across all education bands (foundation, GET, FET) (SouthAfrica.info, 2012). The majority (56%) of the Mathematics teachers in the Western Cape taught in Afrikaans and 46% delivered the Mathematics curriculum in English (Table 5.1).

5.2.7 Qualification

In 2011 the CHET developed a policy aligned with the NQF and the current school curriculum which stipulated the minimum qualifications requirements for teachers in South Africa. Teachers in South Africa should have a minimum qualification at NQF level eight which is a Higher Diploma in Education (HDE) or an Advanced Certificate in Education (ACE) (§ 3.3.1.1) (Department of Education, 2011). Mathematics teachers' qualifications (30%) in the Western Cape were on par with the qualifications framework as stipulated in the policy. Only 7% of the Mathematics teachers held a NQF level five qualification. Fourteen per cent of the Mathematics teachers had post-graduate degrees (Table 5.1). In 2009 in the WCED, 66% of female and 64% of male Mathematics teachers in the GET held acceptable qualifications to teach Mathematics as a specialised subject (Western Cape Education Department, 2009).

5.2.8 Subject Specialisation

Mathematics is a core subject in the curriculum, as well as an area of specialisation and has been identified as a national priority for improvement in the foundation phase, GET and FET (Department of Education, 2007). The SMTs of schools require a Mathematics qualification as pre-requisite for new appointments. Many Mathematics teachers (84%) held a qualification in Mathematics. However, 16% of the Mathematics teachers had majored in other subjects (Table 5.1) which could be an early indication of insufficient PCK to teach Mathematics (Shulman, 2004:188).

5.2.9 School Districts

All the EMDCs in the Western Cape participated in the completion of the questionnaire. The Overberg district represented the least participants. With the initial sample selection, fourteen schools in the Overberg district were selected to participate in the survey (Table 4.4). Many of the schools were located in rural areas and they were difficult to reach within the given timeframe of the data collection (Addendum 4.15:282-283). The researcher was able to visit five of these schools on allocated two days to complete the questionnaire (Addendum 4.12)The remaining seven districts of which the Cape Winelands covered the largest geographical area were well represented (23%) in the data (Table 5.1).

5.2.10 School Quintiles

In South Africa, schools are divided in five quintiles (Table 4.6). Mathematics teachers from all the quintiles participated in this survey. Five per cent of Mathematics teachers from independent schools completed the questionnaire. The majority of the Mathematics teachers (32%) originated from quintile five schools (Table 5.1) who receive a meagre R165 per learner annually from the DBE (Investopedia, 2013a).

5.2.11 Type of School

The WCED covers a large geographical area with schools situated in farm, rural, urban, and semi-urban areas (Figure 4.1). All types of schools were represented in the data. The majority of the participating schools (36%) were situated in semi-urban areas (Table 5.1).

5.2.12 Number of Learners

The majority of the Mathematics teachers (43%) who completed the survey taught at schools comprising more than a thousand learners. Seventeen per cent of the participants taught at schools with less than 500 learners, and 39% taught at schools where there were between 500-1000 learners registered on the EMIS database (Addendum 5.1) (Table 5.1).

5.2.13 Number of Computer Laboratories

A small percentage of the schools (5%) did not have any computer facilities available for the teaching and learning of Mathematics or administration. Some of these schools were funded by the Khanya project (Western Cape Education Department, 2011), but their facilities were outdated, stolen, or vandalised and many of the SMTs of the schools were not pro-active in their initiatives to upgrade, protect, and repair the computers for teachers and learners to use (Addendum 4.15). Figure 5.1

illustrates a school in the WCED where the SMT of the school had a bolted metal door to prevent burglary.

Figure 5.1: Computer Laboratory Bolted with a Metal Door

At another school, the computers were stacked under the workstations and the computer laboratory was no longer used for teaching and learning (Figure 5.2).

Figure 5.2: Khanya Laboratory with Computers under Workstations

The majority of the schools (48%) had at least one computer centre to deliver and support curriculum delivery and development. The schools (15%) which performed well, showed innovation, and had the financial means to equip their schools with additional computer centres for teaching and learning. Many of the quintile five (well-resourced) schools had more than one computer laboratory for curriculum delivery. One of the selected schools had six computer laboratories where teachers could utilize the facilities for teaching and learning across learning areas.

5.2.14 Overall Computer Available

The majority of the schools (95%) had access to computers for administration. The nationally used EMIS was available for WCED teachers relating to administration relating to attendance, lesson planning, assessment, progression and promotion. Many schools had a separate section either in the staffroom or elsewhere with computers which teachers could use for their planning and administration (Figure 5.3).

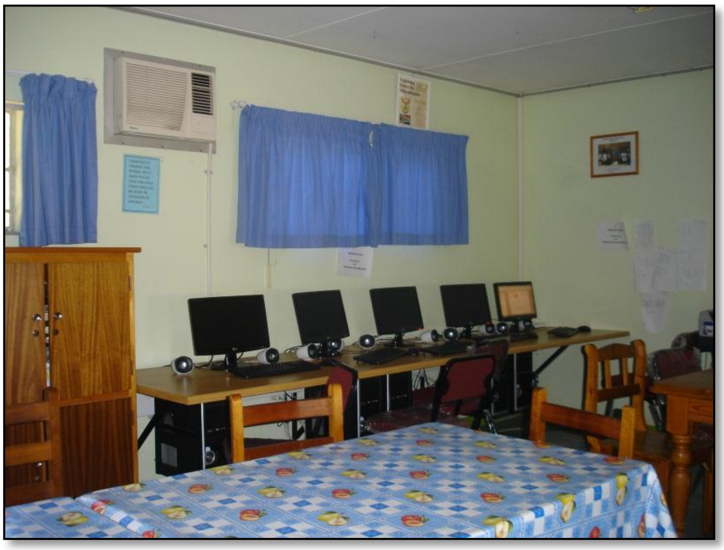

Figure 5.3: Computers for Planning and Administration

Most of the schools (81%) had computers available for general teaching and learning. This is an indication that schools realised the value ICT can bring to the general planning of Mathematics tasks. Only 13% of the Mathematics teachers indicated access to computers for teaching and learning. More grade 8 (46%) and grade 9 (52%) Mathematics teachers had ICT facilities for teaching and learning (Table 5.1). However, if South African schools want to successfully compete with other education systems across the globe, all schools should have access to computers, especially in classrooms, and not in isolated computer centres where teachers and learners have limited access (Daly *et al.*, 2009:10).

5.2.15 Computers with Internet Access

The majority of the schools (95%) indicated computers with Internet access. Many schools (71%) had computers with Internet access where Mathematics teachers were able to: (i) complete their administrative tasks, (ii) retrieve resources, (iii) prepare example lessons, and (iv) collaborate with their peers (Figure 5.1). These circumstances also created the opportunity for Mathematics teachers to participate in PD activities in order to develop their SPI and the ZPD (Low, 2013:80; Vygotsky, 1978a) which are contributing features for the all-inclusive development of Mathematics as a learning area. However, currently there are no existing opportunities and platforms for teachers to participate in PD activities on this level (§ 3.4.1.6). Thirteen per cent of the grade 7 Mathematics teachers had computers with Internet access for teaching their learners Mathematics. More grade 8 (42%) and grade 9 (48%) teachers had computers with Internet access for curriculum delivery. If all Mathematics teachers were able to have computers with Internet access, they could explore the multiple resources of the WWW and develop their TPACK (Attwell & Hughes, 2010:28; Daly *et al.*, 2009:59). It is a known fact that the more teachers have the opportunity to explore with ICT, the more confident and knowledgeable they become in using it in their daily teaching and learning practices (Daly *et al.*, 2009:83).

5.2.16 Computer Literacy Level

Few of the Mathematics teachers (6%) rated their computer skills as poor. While about a quarter of the Mathematics teachers (24%) regarded their computer literacy as fair, the majority (51%) felt competent in order to engage with the ICT equipment. Seventeen per cent of the Mathematics teachers regarded their computer skills as excellent. Khanya provided teachers in the WCED with basic ICT training. Therefore, the majority of Mathematics teachers had exposure to basic computer literacy training (Western Cape Education Department, 2011). Teachers with outstanding computer skills were invited to attend WebQuest and IntelTeach training (SchoolNet SA, 2012). However some of the contextual factors at schools hampered the use of ICT at schools and the development of ICT knowledge and skills (Daly *et al.*, 2009:23). A Mathematics teacher who participated in this survey was frustrated with the SMT of the school who refused to install the delivered new server in the Khanya laboratory (Addendum 4.15:24-25). This was an indication of the importance of school governance for the integration of ICT (Education Labour Relations Council, 2003:A53) (§3.2). The SMT should create a positive culture for ICT use and create opportunities for Mathematics teachers to develop their ICT literacy (Daly *et al.*, 2009:57) (§3.2).

5.2.17 Personal Computers

Of the Mathematics teachers (65%) indicated they had a personal computer at school which they used for teaching and learning. Most of them (86%) were able to work on their planning at home as they had a personal computer which they could use. This was not satisfactory as the aim of the DBE was that all teachers should have a laptop for curriculum delivery by 2011 (§ 3.2.1.4). The DBE had failed to deliver on their promise (Mahlong, 2012).

5.2.18 Access to the Internet

The majority of Mathematics teachers (89%) had access to a computer with Internet at school and many (65%) had Internet access at their homes as well. This indicated that PD could be conducted in an ODL mode if the WCED should consider this mode of training.

5.2.19 Interactive Whiteboards

More than half (54%) of the Mathematics teachers had access to an IWB which they could interactively use for the teaching and learning of Mathematics. An IWB is a useful tool for ICT integration and collaboration in a Mathematics classrooms as it could be used as an interactive tool for peer coaching during the development of TPACK (Jang, 2010:1744). Although not essential, it is disheartening that 46% of the Mathematics teachers did not have access even to a nearby IWB.

5.2.20 Online Courses

The DBE encourage DE as service delivery for the PD of Mathematics teachers in the GET and FET bands (Department of Education, 2012a:71-72). However this is a new mode of service delivery and only a small percentage (11%) of the Mathematics teachers indicated previous participation in online courses. The majority of the Mathematics teachers (89%) had not attended online courses before (Table 5.1). The WCED should explore the possibilities of PD within an ODL platform as it offers many possibilities to the Mathematics teachers, particularly regarding the development of their SPI (§ 3.4.1.1) (Da Ponte *et al.*, 2002:94).

5.2.21 Utilisation of Information and Communication Tools

Items B19 and B20 were included to cultivate an overall view of the usage of ICT tools for both personal and curriculum purposes. Table 5.2 listed the frequencies and percentages of ICT tools (cellular phones, computers and iPads) for general use.

Table 5.2 General Use of ICT Tools

General Use	Cellular devices				Computers				iPads			
	Yes		No		Yes		No		Yes		No	
	N	%	N	%	N	%	N	%	N	%	N	%
Banking	138	46	162	54	98	33	202	67	8	3	292	97
Surfing the Web	151	50	149	50	194	65	106	35	16	5	284	95
Chatting	244	81	56	19	113	38	187	62	15	5	285	95
Playing games	75	25	225	75	86	29	214	71	7	2	293	98
Shopping online	17	6	283	94	57	19	243	81	5	2	295	98

Table 5.2 provides an indication of how Mathematics teachers used cellular phones, computers and iPads for everyday tasks. The majority of Mathematics teachers (81%) used their cellular phones to chat with friends, family and peers. Very few (94%) of the Mathematics teachers used their cellular

phones for online shopping. Mathematics teachers (65%) frequently used the computer to search the WWW, but to a lesser extent (67%) for banking. Only 5% of the Mathematics teachers made use of iPads (Table 5.2).

Table 5.3 provides the frequencies and percentages for the school use of ICT tools (cellular devices, computers, and iPads).

Table 5.3 ICT Tools for School Use

School Use	Cellular devices				Computers				iPads			
	Yes		No		Yes		No		Yes		No	
	N	%	N	%	N	%	N	%	N	%	N	%
Communicate with teachers	121	40	179	60	122	41	178	59	7	2	293	98
Search for materials	54	18	246	82	203	68	97	32	11	4	289	96
Prepare lesson content	26	9	274	91	205	68	95	32	10	3	290	97
Plan instruction	22	7	278	93	189	63	111	37	7	2	293	98

The use of cellular phones was less popular for teaching and learning purposes. Mathematics teachers (40%) used cellular phones to communicate with other teachers. Mathematics teachers (68%) preferred to use computers to prepare their lessons and search for teaching and learning material. Very few Mathematics teachers made use of iPads for school purposes (Table 5.3).

5.2.22 Professional Development Models

Part G of the questionnaire (Addendum 4.11) included four PD models conceptualised from various models discussed in the literature probe (§3.5.1.6). The Mathematics teachers had to select the two of these models most appropriate to their PD preference and needs. Table 5.4 provides the frequencies and percentages for Part G (PD models) of the questionnaire.

Table 5.4 Frequencies and Percentages of Professional Development Models

PD Model	Frequencies	Percentages
Model 1	188	63
Model 2	128	43
Model 3	142	47
Model 4	54	18

The results for the four models were as follows:

- Model 1: The majority of the Mathematics teachers (63%) selected Model 1 as the preferred model for PD. Model 1 includes PD activities arranged by the WCED in collaboration with the CAs, SMTs, and HODs of the schools. Mathematics teachers prefer PD within their subject group and to attend scheduled training session. Within their school contexts they are able to socialise and reflect on their Mathematical capabilities and shortcomings. Mathematics teachers could create and connect ideas; share experiences and learn in their subject group (Anderson, 2002:129); accept feedback from their peers; defend their ideas, air views and opinions; develop lessons and discuss their best practices with their colleagues (Aceto *et al.*, 2010:6; Da Ponte, 2010:5; Loveless, 2011:306).

- Model 2: Less than half of the Mathematics teachers (43%) chose Model 2 which was quite similar to Model 1, but excluded the involvement of the SMT and HOD. This substantiates the importance of the WCED, CAs, HODs, and SMTs in the developmental process (Daly *et al.*, 2009:57; Rodriguez, 2000).
- Model 3: More than half (47%) of Mathematics teachers chose Model 3 as another option for PD. Model 3 could take place in either a face-to-face context or in an online environment. Mathematics teachers felt that the involvement of the SMT was critical in PD (§3.2), but their individual needs should also be catered for (Daly *et al.*, 2009:57).
- Model 4: This model was an online PD model and few Mathematics teachers (18%) chose this mode of training. Mathematics teachers favoured the traditional mode or face-to-face training. This finding could also relate the novelty of ODL for PD as they had little or no experience on which to authenticate their choice.

The following section discusses the factor analysis conducted on Parts C, D, E, and F of the questionnaire.

5.3 Factor Analysis

A principal axis factor analysis with Oblimin rotation was conducted on Parts C, D, E, and F of the questionnaire (Addendum 5.3). The factor analysis validated the correlation coefficient between the factors. The shaded areas in the tables indicate the group items loading on each factor. All factor loadings ≤0.3 were deleted from the tables. The variables which had more than one factor loading were grouped according to the best interpretability.

5.3.1 Reliability of the Factors

The reliability test of the factors was performed using Cronbach's Alpha. Nunnally (1978:276) states that a questionnaire can be confirmed as reliable when the Cronbach Alpha coefficient is ≥0.7. For the alpha coefficient the following applied to this factor analysis: >0.90 very highly reliable; 0.80-0.90 highly reliable; 0.70-0.79 reliable; 0.60-0.69 marginally reliable; and ≤0.60 low reliability (Cohen *et al.*, 2011:640). A reliability level of 0.7 was considered acceptable for the factor analysis (Cohen *et al.*, 2011:639-640). The questionnaire included subscales therefore the reliability of each set of factors was calculated individually using Cronbach's Alpha (Field, 2013:709).

5.3.2 Results of Factor Analysis of Governance

The 23 items in Part C of the questionnaire focused on the governance of ICT implementation (§4.5.8.2) at provincial (WCED), district and school level (Addendum 4.11). The factor analysis grouped the 23 items into four clusters. Table 5.5 provides the pattern matrix of the factor analysis of the 23 items of Part C of the questionnaire on governance.

Table 5.5 Factor Analysis of Governance

Items		Factor			
		1	2	3	4
C7	The WCED provides Mathematics teachers with Webquest training	0.569			
C8	The WCED offers IntelTeach training to Mathematics teachers	0.652			
C9	The circuit stimulates the development of ICT in Mathematics teaching and learning	0.898			
C10	The circuit provides professional development in ICT integration in Mathematics	1.004			
C11	The circuit motivates Mathematics teachers to share their practices with ICT	0.906			
C12	The circuit creates an online network where Mathematics teachers share practices	0.763			
C13	My school supplies computers for administrative purposes		0.309		0.301
C14	My school installs computers for teaching and learning of Mathematics		0.486		0.364
C19	My school provides time for Mathematics teachers to use the ICT facilities at school to prepare lessons		0.520		
C20	My school supports the use of ICT in the teaching and learning of Mathematics		0.628		
C21	My school creates a timetable for Mathematics teachers to use the ICT facilities for teaching and learning		0.819		
C22	My school encourages Mathematics teachers to use the ICT facilities for teaching and learning		0.826		
C23	My school supports online Mathematics networks		0.533		
C1	The WCED motivates the use of ICT in Mathematics teaching			0.485	
C2	The WCED allocates funds for ICT Mathematics training			0.617	
C3	The WCED gives funds for ICT resources			0.610	
C4	The WCED provides my school with computers for administration			0.833	
C5	The WCED supplies my school with computers for teaching and learning			0.653	
C6	The WCED gives training to Mathematics teachers in ICT integration			0.404	
C15	My school provides IWB for the teaching and learning of Mathematics		0.308		0.440
C16	My school supports ICT professional development activities from external providers				0.691
C17	My school provides access to the educational PORTAL (Thutong)				0.653
C18	My school supports ICT PD activities initiated by the WCED				0.657
	Cronbach's Alpha	0.95	0.85	0.81	0.88
	Mean	3.26	2.92	3.24	3.24
	Standard Deviation	1.204	0.768	0.977	0.926

The factor analysis clustered the items in Part C of the questionnaire into four homogeneous groups (Garrett-Mayer, 2006b). The factor analysis revealed four factors (Table 5.5) which were extracted according to the Kaiser's criteria that all factors with eigenvalues larger than one is extracted (Field, 2009:647). Six variables clustered as Factor 1, seven variables clustered as Factor 2, six variables clustered as Factor 3, and four variables clustered as Factor 4. The majority of the factors show a factor loading of ≥0.6. The KMO measure of 0.912 indicated adequate data for factor analysis (Cohen et al., 2011:641). The Barlett's test of sphericity showed a significance of $p<0.0001$ for this factor analysis (Cohen *et al.*, 2011:641). The four extracted factors explained a total variance of 59%. Communalities varied from 40% for Factor 1, 50% for Factor 2, 55% for Factor 3, and 59% for Factor 4. A thorough scrutiny revealed that Factor 1 corresponds with Responsibility of DBE, Factor 2 relates to Responsibility of management, Factor 3 associates with Responsibility to teaching and learning, and Factor 4 corresponds with Policy initiatives. The extracted factors showed a high reliability with a

Cronbach Alpha ≥0.7: Responsibility of the DBE (0.95); Policy initiatives (0.85), Responsibility of management (0.81), and Responsibility to teaching and learning (0.88) (Table 5.5) (Addendum 5.4).

The four variables of Factor 1 (responsibility of the DBE) emphasised the responsibility of the DBE regarding the delivery of PD of Mathematics teachers (Table 5.5). The responsibility of the DBE (§ 3.2.1.4) is to oversee the implementation of ICTs in schools, and to guarantee that the systems are in place for Phase III of the e-Education policy (Department of Education, 2004b:19). Therefore the DBE is responsible to supply Mathematics teachers with quality PD for Phase III implementation. The mean of 3.26 indicated that the respondents agreed on aspects regarding the responsibility of the DBE.

Factor 2 (responsibility of management) focused on the responsibility of the school towards the administration and implementation of ICT for the teaching and learning of Mathematics in schools (Table 5.5) (§4.5.8.2). The SMT of the school should have an ICT strategic plan which includes: (i) supplying ICT resources for administration, teaching and learning, and communication; (ii) providing time for teachers to prepare their ICT lessons; (iii) creating a timetable for Mathematics teachers to use ICT facilities; and (iv) encouraging teachers to use ICT for the teaching and learning of Mathematics (§ 3.2.1.6). The mean of 2.92 indicated that there was difference in opinion regarding the role of management for ICT integration in schools.

The six variables of Factor 3 (policy initiatives) evaluated the provision of funds, resources and PD of Mathematics for Phase III implementation. In 2002 with the formation of the PIAC on ISAD many initiatives were launched by the DBE and the PDEs to integrate ICT for curriculum delivery. However, these initiatives (§ 3.2.1.5) did not focus on the aims of the three phase plan of the e-Education policy (Blignaut & Howie, 2009:662). The mean of 3.24 indicated the respondents agreed on the status of policy initiatives (Table 5.5).

The four variables of Factor 4 (responsibility to teaching and learning) focused on the schools' responsibility to assist Mathematics teachers to access support mechanisms (Portal and PD) for Mathematics curriculum delivery (§ 3.2.1.5). The mean of 3.24 indicated that the Mathematics teachers felt the same about the schools' responsibility towards curriculum support.

5.3.3 Factor Analysis of School Environment

The twelve items in Part D of the questionnaire focussed on the extent to which Mathematics teachers create a classroom environment for ICT integration (Addendum 4.11) (§ 4.5.8.3). Table 5.6 provides the pattern matrix of the factor analysis of the twelve items on School Environment (Addendum 5.3).

Table 5.6 Factor Analysis of School Environment

Items		Factor 1	Factor 2
D1	I use social software for personal use, e.g. email, Facebook, Twitter, Mxit, Whatsapp, BBM	0.692	
D2	I use the Internet to find Mathematics resources	0.480	
D3	I use ICT in Mathematics teaching to achieve the Learning Outcomes	0.319	0.619
D4	I develop lessons to use ICT in Mathematics teaching	0.231	0.713
D5	I use a variety of teaching methods with ICT in my Mathematics class		0.865
D6	I decide which ICT applications to use in Mathematics teaching and learning		0.814
D7	I assist my learners to use ICT in Mathematics lessons		0.856
D8	I take responsibility for my own learning regarding the integration of ICT in Mathematics teaching		0.614
D9	I have a positive attitude towards ICT for teaching and learning Mathematics	0.324	0.345
D10	I carry out Mathematics investigations with my learners through ICT		0.903
D11	I stimulate my learners to be creative with ICT		0.901
D12	I use ICT to accommodate the diverse group of learners in my class		0.909
	Cronbach's Alpha	0.58	0.94
	Mean	3.19	2.71
	Standard Deviation	0.601	0.709

As seen from the pattern matrix in Table 5.6, the items of Part D of the questionnaire clustered into two factors according to the Kaiser criteria. The criteria determined that factors with Eigen values larger than one should be extracted (Field, 2009:647). The KMO measure of 0.906 indicated sufficient data to conduct a factor analysis (Cohen *et al.*, 2011:641). Two variables clustered in Factor 1, and ten variables clustered in Factor 2 (Table 5.6). Most of the factors showed a factor loading ≥0.6. The Barlett's test of sphericity showed a significance of $p<0.0001$ for this factor analysis (Cohen *et al.*, 2011:641). The two extracted factors show a total variance of 61%. Communalities varied from 53% for Factor 1, and 61% for Factor 2. An in-depth examination disclosed that Factor 1 corresponds with *TK*, and Factor 2 relates to *TPACK*. Technological knowledge showed a Cronbach Alpha of ≤0.7, therefore indicated low reliability, but TPACK showed high reliability with Cronbach Alpha of 0.94 (Addendum 5.4).

The two variables clustered in Factor 1 (TK) related to TK of Mathematics teachers (Table 5.6). TK is difficult to define (Koehler & Mishra, 2009:64), but the concept of Fluency of Information Technology (FITness) closely describe TK. FITness includes three separate, but unified elements—abstract knowledge, conceptual knowledge, and adequate skills. Mathematics teachers who cultivate these capabilities, knowledge, and skills become *fluent with technology* (FIT) (National Research Council, 1999:14). A FIT Mathematics teacher uses ICT in a private and specialised capacity. FITness in context of Mathematics teaching require teachers to understand ICT sufficiently to use it in their daily lives, employ ICT in their work environment, and to identify when ICT can assist with the achievement of learning outcomes (Koehler & Mishra, 2009:64; National Research Council, 1999:14).

Factor 2 (TPACK) corresponded with TPACK (Table 5.6). TPACK is the foundation of executing knowledge with technology (§ 3.3.1.1). Mathematics teachers with adequate TPACK have: (i) the pedagogical skills to utilise ICT to impart knowledge, (ii) the ability to distinguish the level of complexity of mathematical concepts, (iii) the knowledge to select the appropriate ICT to assist learners to solve mathematical problems, (iv) an awareness of their learners' level of competencies, and (v) the knowledge to select ICT to construct new mathematical knowledge based on their learners' prior knowledge (Koehler & Mishra, 2009:66).

The mean of 2.71 for TPACK indicated that Mathematics teachers regarded TK more important than TPACK.

5.3.4 Factor Analysis of Information and Communication Technologies

The ten items in Part E of the questionnaire (Addendum 4.11) focused on the use of ICT in the Mathematics classroom (§ 4.5.8.4). Table 5.7 provides the pattern matrix of the factor analysis of the ten items on ICT.

Table 5.7 Factor Analysis of Information and Communication Technologies

Items		Factor	
		1	2
E1	My school negotiates with service providers for reliable Internet access	0.661	
E2	My school has an ICT policy	0.839	
E3	My school has teachers who use ICT innovatively	0.514	
E4	My school's ICT vision aligns with the latest trends in the curriculum	0662	
E5	I plan my ICT integration Mathematics activities in advance		0742
E6	I communicate with remote colleagues through ICT		0.828
E7	I am confident to use the ICT applications in my Mathematics lessons		0.732
E8	I do not use ICT in the teaching and learning Mathematics despite the affordances for teaching and learning		0.461
E9	I use ICT for assessment of Learning Outcomes		0.934
E10	My learners gain ICT competency when I use ICT in my Mathematics lessons		0.704
	Cronbach's Alpha	0.80	0.88
	Mean	3.26	2.62
	Standard Deviation	0.917	0.774

The factor analysis clustered the ten variables in Part E of the questionnaire (Table 5.7) into two homogeneous groups which gave the researcher insight into the categories (Garrett-Mayer, 2006b). The Kaiser criteria determined that factors with Eigen values larger than one should be extracted (Field, 2009:647). The KMO measure of 0.893 indicated adequate data for factor analysis (Cohen *et al.*, 2011:641). Four variables clustered in Factor 1, and six variables clustered in Factor 2. The majority of the factors showed a factor loading of higher than 0.6 (Table 5.7). The Barlett's test of sphericity showed a significance of $p<0.0001$ for this factor analysis (Cohen *et al.*, 2011:641). The two extracted factors show a total variance of 55%. Communalities varied between 46% for Factor 1, and 55% for Factor 2. A thorough examination revealed that Factor 1 relates to contributors of SPI, and Factor 2 corresponds with ICT and SPD. Contributors to SPI showed a high Cronbach Alpha reliability of 0.80 and ICT and SPD also indicated a high reliability of 0.88 (Addendum 5.4).

The four variables clustered in Factor 1 (contributors to SPI) related to the features within the school environment which contribute towards the SPI (Table 5.7). The SPI of Mathematics teachers focuses on the holistic growth of Mathematics teachers through self-awareness and constructive socialisation (§ 3.3.1.5) (Leont'ev, 1978; Rynänen, 2001:98). The SMT of the school should make sure that the school's ICT vision is aligned with the latest ICT developments so that Mathematics teachers embrace the critical functions, rules and principles of the teaching profession (Da Ponte *et al.*, 2002:146). Mathematics teachers should have access to ICT resources, Internet access, and expert teachers to establish a community of practices where they can discuss their uncertainties, communicate ideas and best practices with their peers and colleagues (Hartsell *et al.*, 2009:62).

Six variables grouped in Factor 2 (ICT and SPD) linked to what extend the use of ICT within the teaching and learning add to SPD of Mathematics teachers within their school environment (Table 5.7). ICT if use constructively has the ability to transform the nature of Mathematics teachers' social identity (§ 3.3.1.3) (Chute *et al.*, 1999:4). Mathematics teachers become skilled the more they use the massive collection of tools available on the Internet for planning, teaching and learning, and assessment (Enochsson & Rizza, 2009). In the process they develop as experts which means their confidence increase, they use CMC to share their competencies with their colleagues and peers, their own as well as their colleagues grow cognitively and acquire knowledge (Vygotsky, 1978a:78). All of the above contribute to their SPD.

The mean of 2.62 for ICT and SPD indicated that Mathematics teachers regarded contributors of SPI as more important than ICT and SPD.

5.3.5 Factor Analysis of Professional Development

The nineteen items in Part F of the questionnaire (Addendum 4.11) focused on the PD of Mathematics teachers in a various contexts and through multiple strategies (§4.5.8.5). Table 5.8 provides the pattern matrix of the factor analysis of PD.

Table 5.8 Factor Analysis of Professional Development

Items		Factor		
		1	2	3
F1	I should develop my Mathematics competencies myself		0.447	
F2	I should know about the current trends in Mathematics education		0.755	
F3	I should be innovative with ICT in my Mathematics teaching		0.769	
F4	I should use ICT to communicate with other Mathematics teachers		0.918	
F5	I should share ICT practices with other Mathematics teachers		0.755	
F6	I should share my views in an online environment		0.380	
F7	I should network with other Mathematics teachers		0.529	
F8	I should attend ICT Mathematics professional development training according to my individual needs		0.335	-0.427
F9	I should attend ICT Mathematics professional development based at my own pace			-0.330
F10	I should receive ICT subject specialized professional development training			-0.892
F11	I should be attend ICT professional development training at my school	0.377		-0.451
F12	I should attend online ICT Mathematics professional development training	0.655		
F13	I should combine face to face and online ICT Mathematics professional development training	0.684		
F14	I should receive classroom support based training and mediation where trainers visit my classroom	0.803		
F15	I should advance my ICT Mathematics professional development	0.773		

Items		Factor		
		1	2	3
	through distance learning			
F16	I should have access a lead teacher at my school during ICT professional development training	0.716		
F17	I should attend ICT professional development Mathematics training to suit the context and needs of my school	0.831		
F18	I should have access to joined WCED and district ICT professional development training	0.753		
F19	I should have access to ICT professional development guidelines on the integration of ICT in the teaching and learning of Mathematics	0.723		
	Cronbach's Alpha	0.92	0.87	0.87
	Mean	3.19	3.23	3.26
	Standard Deviation	0.548	0.450	0.503

During the factor analysis, the nineteen variables clustered into three homogeneous groups which enabled the researcher to gain insight to categories (Garrett-Mayer, 2006b). The KMO measure of 0.927 indicated adequate data for factor analysis. The Kaiser criteria determined that factors with Eigen values larger than one should be extracted (Field, 2009:647). Eight variables clustered in Factor 1, seven variables grouped in Factor 2, and four variables assembled in Factor 3 (Table 5.8). Most of the factors showed a factor loading of ≥0.6. The Barlett's test of sphericity showed a significance of ≤0.0001 for this factor analysis (Cohen *et al.*, 2011:641). The three extracted factors explained a total variance of 61%. Communalities varied between 50% for Factor 1, 57% for Factor 2, and 61% for Factor 3. An in-depth examination revealed that Factor 1 related to *teachers' expectations for PD*, Factor 2 corresponded with *Building a* SPI, and Factor 3 could be associated with PD models and frameworks. Teacher expectations for PD showed a high Cronbach Alpha reliability of 0.92. Building a SPI showed a high reliability of 0.87 and ICT and SPD also indicated a high reliability of 0.87 (Addendum 5.4).

Eight variables clustered in Factor 1 (teachers' expectations for PD) which focused on what the types of PD activities Mathematics teachers expected form the DBE, PDE and schools. Mathematics teachers preferred to attend PD training within their school context, based on their individual professional requirements, and within a subject network group (§ 3.5.1.6). Therefore the DBE, PDE and CAs should work with the HODs and derive a PD plan and approach which adhere to these needs. Mathematics teachers should give their cooperation and become enthusiastic about the PD initiatives if their needs are addressed during PD (Broadley, 2011:187; Daly *et al.*, 2009:54).

The seven variables grouped in Factor 2 (Building a SPI) related to some of the external and internal contributors of the professional identity of Mathematics teachers (§ 3.4.1.1). The external contributors focused on Mathematics teachers' responsibility to develop their professional skills, and adhere to the current tendencies in the curriculum. The internal contributors relate to Mathematics teachers' attitude and self-commitment to develop their mathematical knowledge and skills (Da Ponte, 2010:145). When the external and internal contributors are in place, Mathematics teachers will build a SPI.

Four variables clustered as Factor 3 (PD models and frameworks) which related to the PD activities for Mathematics teachers. The ideal PD model for Mathematics teachers includes (i) a structure which allows them to develop at their own pace, (ii) subject-specialised training, (iii) activities based on their developmental needs, and (iv) school-based training (Daly *et al.*, 2009:82).

The subsequent section discusses how the eleven factors clustered from Parts C, D, E, and F of the questionnaire, during the factor analysis, form the interactive elements of an activity system. The eleven factors are in congruence with the literature codes conceptualised as interrelated components of the four activity systems during the adjustable exploration phase of this complex research (Figures 3.3, 3.6, 3.9, and 3.12).

5.3.6 Factors Conceptualised as Elements of Activity Theory

As explained in § 1.3.1.5, Engeström's third generation activity theory was used as the conceptual framework for this study. The four factors from Part C (Responsibility of DBE, Policy initiatives, Responsibility of management, Responsibility to teaching and learning), the two factors from Part D (TK and TPACK), the two factors from Part E (Contributors to SPD, ICT and SPD), and the three factors from Part F (Building a SPI, PD models and frameworks, Teacher expectations for PD), were identified as core components in the context of transformation thus to *develop the guidelines for the PD of Mathematics teachers in the pedagogical use of ICT in ODL*. This formed part of (Phase II) the radical exploration phase of the research (§ 1.3.1.6).

Figure 5.4 displays the *Triangular Activity System* (TAS) with the eleven factors clustered as interactive components of an activity system.

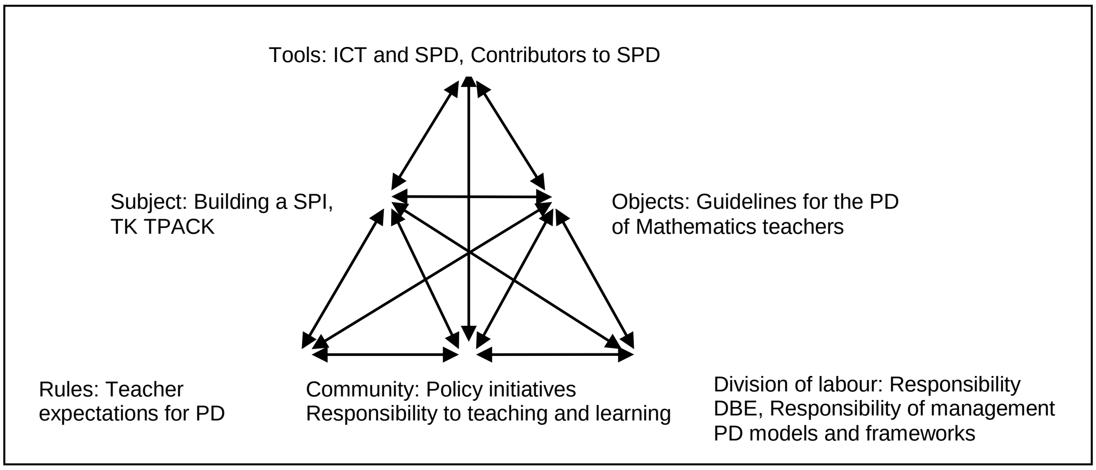

Figure 5.4: Triangular Activity System (Adapted from (Engeström, 1987))

The object of the TAS was to develop guidelines for the PD of Mathematics teachers for the pedagogical use of ICT (Phase III of the e-Education policy) in ODL. The subject (Building a SPI, TK, and TPACK) is influenced by tools (ICT and SPD, and contributors to SPD) which contributed towards achieving the object of the activity. The community comprised of the policy initiatives by the DBE, and its responsibility to teaching and learning. The Mathematics teachers' PD is mediated by teachers' expectations for PD. In order for guidelines to be effective, the role players in education (DBE, PDE, CAs, and school management) should adhere to their responsibilities to create a PD model and framework best suited to Mathematics teachers' needs. The six interrelated units of the TAS individually and cooperatively promoted the development of the guidelines for PD of Mathematics teachers in the pedagogical use of ICT in ODL. Table 5.9 provides a summary of the findings from the factor analysis imbedded in components of the TAS.

Table 5.9 Professional Development of Mathematics teachers in the pedagogical use of ICT in ODL According to the Triangular Activity System

AT Object	AT Elements	Triangular Activity System
Subject	Building a SPI	• Mathematics teachers adhere to the roles and responsibilities of the teaching profession • Mathematics teachers self-commit to develop their professional capabilities
	TK	• Mathematics teachers should have FITness: abstract knowledge, conceptual knowledge, and ICT skills
	TPACK	• Mathematics teachers should have pedagogical skills • Mathematics teachers must be able to distinguish between level of complexity of mathematical problems • Mathematics teachers should know their learners' competencies • Mathematics teachers should know how to construct new knowledge using prior knowledge
Tools	ICT and SPD	• Schools should use ICT to transform the nature of Mathematics teachers' social identity • Mathematics teachers should use ICT regularly to develop knowledge, skills and confidence
	Contributors to SPD	• Schools ICT vision should align with changes in the curriculum • Schools should have structures in place so that Mathematics teachers adhere to the roles and responsibilities of the teaching profession
Rules	Teacher expectations for PD	• PD should focus on their individual needs • Mathematics teachers aspire to network with colleagues and peers • DBE, PDE, CAs and HODs derive a PD plan
Community	Policy initiatives	• DBE supply funds, resources and ICT integration PD
	Responsibility to teaching and learning	• ICT integration plan and strategies
Division of Labour	Responsibility of DBE	• DBE should supply quality PD for Phase III of the e-Education policy
	Responsibility of management	• SMT derive an ICT integration strategic plan
	PD model and framework	• PD school contextualised model • PD subject-specialised training

The following section presents the results from the comparisons between the elements of the TAS and the biographical information in Parts A and B of the questionnaire (Addendum 4.11).

5.4 Comparisons between Biographical Information and the Elements of the Triangular Activity System

Hierarchical linear modelling was used in order to measure whether there were differences between the biographical information in Part A and Part B of the questionnaire and the elements from

Governance (Responsibility of DoE, Policy initiatives, Responsibility of management, Responsibility to teaching and learning) (§ 3.2), School Environment (TK and TPACK) (§ 3.3), ICT (Contributors to SPD, ICT for SPD) (§ 3.4), and PD (Building a SPI, PD models and frameworks, Teacher' expectations for PD) (§ 3.5). Two sets of calculation were used to determine the relationship: hierarchical linear models using SPSS (Addendum 5.5) for the categorical items in the questionnaire; and SAS models for all the items measured on an interval scale in the questionnaire (Addenda 5.6-5.8). These were both examples of hierarchical linear models. As the items in Part A and Part B were arranged in a hierarchical structure with varying parameters using multilevel models, the researcher was able to measure whether there was a relationship between the biographical information and the elements of Guidelines activity system (Field, 2013:828).

5.4.1 Descriptive statistics on Elements of Triangular Activity System and Results of Hierarchical Linear Modelling

Items A1, A5, A6, A7, A8, B1, B4, and B6 were correlated with the factors (elements of TAS) to measure if there were differences between the elements and the biographical information in Part A and Part B of the questionnaire (Addendum 4.11). For this analysis all teachers of the same school were considered to be dependent on the school. Cohen (1988:25-27) proposes scales to interpret the effect sizes measured by $d=0.2$ as small with little or no significant difference, 0.5 as medium that tended towards practically significant difference, and $d \geq 0.8$ large with practically significant difference. Only the medium and large effects were used for this interpretation. The medium and large effects were shaded within the tables. A $p \leq 0.05$ of the model indicated that the means of the groups differed significantly. These two measures were used to interpret the differences in means of the hierarchical linear models.

5.4.1.1 Descriptive Statistics on Elements of Triangular Activity System and the Results of the Hierarchical Linear Modelling, Effect Sizes and Gender Differences

With this association the researcher measured whether the *gender* of the Mathematics teachers had an effect on the elements of TAS, i.e. if there was a significant difference between male and female regarding the elements. Table 5.10 provides the results of hierarchical linear modelling and effect sizes to test for gender differences on the elements of TAS. Table 5.10 provides the descriptive statistics on elements of TAS with the results of the hierarchical linear modelling and the effect sizes to test for gender differences between the male and female Mathematics teachers who participated in the survey.

Table 5.10 indicates a significant effect of gender on responsibility of DBE, $F=6.47$, $p=0.012$, where females felt more positive towards the responsibility of the DBE than males. However, the effect size indicates that this difference is not important in practice (small effect $d=0.30$).

Table 5.10 Descriptive statistics on Elements of Triangular Activity System and Results of Hierarchical Linear Modelling and Effect Sizes to Test for Gender Differences

Elements of TAS		Means		Estimate Residual	P values	Effect sizes (d-values)
		Male	Female			Male with Female
Subject	Building a SPI	3.24	3.23	0.203	0.843	0.02
	TK	3.16	3.22	0.362	0.419	0.10
	TPACK	2.68	2.74	0.504	0.498	0.08
Tools	ICT for SPD	2.54	2.68	0.596	0.119	0.18
	Contributors to SPD	3.04	3.44	0.806	<0.001*	0.45*
Rules	Teacher expectations for PD	3.21	3.18	0.301	0.619	0.05
Community	Policy Initiatives	3.11	3.35	0.846	0.026	0.26
	Responsibility to teaching and learning	3.04	3.40	0.926	<0.002*	0.37*
Division of labour	Responsibility of management	2.79	3.02	0.579	<0.010*	0.30
	Responsibility of the DBE	3.06	3.42	1.423	<0.012*	0.30
	PD models and frameworks	3.28	3.24	0.253	0.512	0.08

*p≤0.05
d≤0.4 small with little or no significant difference
0.5≤0.8 medium that tended towards practically significant difference
d≥0.8 large with practically significant difference

There was a significant effect of gender on policy initiatives, F=5.00, p=0.026, where the females regard the initiatives more positively than the males Mathematics teachers. The effect size indicates that this difference was not important in practice (small effect d=0.26).

Table 5.10 indicates a significant effect of gender on responsibility of management, F=6.70, p=0.010, where females regard the responsibility of management as more important than males. The effect size indicates that this difference is not important in practice (small effect *d*=0.30).

There was a significant effect of gender on responsibility to teaching and learning, F=10.12, p=0.002, where the females regard their responsibility towards teaching and learning more important than the male Mathematics teachers. The effect size indicates that this difference was not important in practice (small effect *d*=0.37).

During SPD Mathematics teachers constructively communicate with their peers regarding their pedagogical beliefs and practices (§ 3.3.1.3). A significant effect was found with gender on contributors of SPD, F=14.10, p=0.001, where females were more positive towards constructive communication with their peers than male counterparts. The effect size indicates that this difference might be important in practice (medium effect d=0.45).

The results in Table 5.10 show that for most of the elements of TAS there were no significant differences between the male and the female Mathematics teachers. Significant differences were found between the female and their male counterparts regarding responsibility of the DBE and management, responsibility to teaching and learning, policy initiatives, and contributors to SPD. These results indicate that female Mathematics teachers might view these elements more important to Phase III implementation of the e-Education policy (Department of Education, 2004b:23).

5.4.1.2 Descriptive Statistics on Elements of Triangular Activity System and the results of the Hierarchical Linear Modelling, Effect Sizes and Home Language Differences

With this association the researcher measured whether the *home language* of the Mathematics teachers had an effect on the elements of TAS i.e. if there was a statistically significant difference between Afrikaans, English, or other indigenous language speaking Mathematics teachers and the elements of TAS.

Table 5.11 (next page) provides the results of hierarchical linear modelling and effect sizes to test for language differences on the elements of TAS.

Table 5.11 Descriptive Statistics on Elements Triangular Activity System and Results of Hierarchical Linear Modelling and Effect Sizes for Home Language

Elements of TAS		Means			Estimate Residual	P values	Effect Sizes		
		English	Afrikaans	Other			English with Afrikaans	English with Other	Afrikaans with Other
Subject	Building a SPI	3.37	3.19	3.23	0.199	<0.028*	0.40*	0.31	0.09
	TK	3.23	3.23	3.05	0.360	0.136	0.00	0.30	0.30
	TPACK	2.65	2.74	2.71	0.505	0.718	0.13	0.08	0.04
Tools	ICT for SPD	2.66	2.66	2.44	0.596	0.171	0.00	0.28	0.28
	Contributors to SPD	3.81	3.37	2.96	0.822	<0.011*	0.49*	0.94*	0.45*
Rules	Teacher expectations for PD	3.32	3.14	3.27	0.297	0.051	0.33	0.09	0.24
Community	Policy Initiatives	3.22	3.24	3.28	0.862	0.948	0.02	0.06	0.04
	Responsibility to teaching and learning	3.08	3.31	3.14	0.949	0.201	0.24	0.06	0.17
Division of labour	Responsibility of management	2.69	3.01	2.82	0.575	<0.011*	0.42*	0.17	0.25
	Responsibility of the DBE	3.24	3.28	3.20	1.457	0.918	0.03	0.03	0.07
	PD models and frameworks	3.34	3.24	3.24	0.253	0.369	0.20	0.20	0.00

*p≤0.05
d≤0.4 small with little or no significant difference
0.5≤0.8 medium that tended towards practically significant difference
d≥0.8 large with practically significant difference

There was a significant effect of language (Afrikaans, English and other indigenous languages) on Building a SPI, F=3.63, p=0.028, where English speaking Mathematics teachers were more aware of who they were as a person, accepted the value of networking with their peers, wanted to develop their mathematical competencies, and adhered to the roles and responsibilities of the teaching profession than Afrikaans speaking Mathematics teachers (d=0.40, medium effect) (Table 5.11).

Table 5.11 indicated a significant effect of language (Afrikaans, English and other indigenous languages) on contributors to SPD, F=4.60, p=0.011. The English speaking Mathematics teachers felt more secure in their environment, were more positive to engage with their colleagues, were willing to observe lessons and communicate their uncertainties (§ 3.3) than Afrikaans speaking Mathematics teachers (d=0.49, medium effect) as well as other language speaking teachers (d=0.94, large effect). Afrikaans speaking teachers score higher than speakers of other indigenous languages concerning contributors to SPD, with effect size of d=0.45 that tended towards practically significant differences (Table 5.11).

Table 5.11 indicated a significant effect of language (Afrikaans, English and other indigenous languages) on responsibility of management, F=4.61, p=0.011. The Afrikaans speaking Mathematics teachers were more positive towards what they regarded as the responsibility of management than English speaking Mathematics teachers. The effect sizes d=0.42 indicated a medium effect which tended towards practically significant differences between English and Afrikaans speaking Mathematics teachers regarding responsibility of management (Table 5.11).

The results in Table 5.11 indicated that there were significant effect of language (Afrikaans, English and other indigenous languages) and contributors to SPD, building a SPI, and responsibility of management.

5.4.1.3 Descriptive Statistics on Elements of Triangular Activity System and the Results of the Hierarchical Linear Modelling, Effect Sizes and Language of Instruction Differences

With this association the researcher measured whether the *language of instruction* of the Mathematics teachers had an effect on the elements of TAS i.e. if there was a significant difference between the elements of TAS for different between languages of instruction groups. Table 5.12 provides the results of hierarchical linear modelling and effect sizes to test for language of instruction differences on the elements of TAS.

Table 5.12 indicated the descriptive statistics on elements of TAS, the results of the hierarchical linear modelling and the effect sizes which tested for differences between means of the elements of TAS for language of instruction groups.

Table 5.12 Descriptive statistics on Elements of Triangular Activity Theory and Results of Hierarchical Linear Modelling and Effect Sizes for Language of Instruction Differences

Elements of TAS		Means			Estimate Residual	P values	Effect sizes (d-values)		
		English	Afrikaans	Other			English with Afrikaans	English with Other	Afrikaans with Other
Subject	Building a SPI	3.31	3.18	3.39	0.200	<0.036	0.29	0.18	0.47*
	TK	3.16	3.22	3.13	0.363	0.706	0.10	0.05	0.15
	TPACK	2.68	2.74	2.45	0.505	0.594	0.08	0.32	0.41*
Tools	ICT for SPD	2.57	2.65	2.58	0.601	0.675	0.10	0.01	0.09
	Contributors to SPD	3.16	3.33	3.19	0.839	0.257	0.19	0.03	0.15
Rules	Teacher expectations for PD	3.31	3.11	3.16	0.293	<0.008	0.37	0.28	0.09
Community	Policy Initiatives	3.26	3.26	2.30	0.850	0.117	0.00	1.04*	1.04*
	Responsibility to teaching and learning	3.15	3.30	3.00	0.954	0.385	0.15	0.15	0.31
Division of labour	Responsibility of the DBE	3.25	3.29	2.21	1.443	0.210	0.03	0.87*	0.90*
	Responsibility of management	2.79	3.00	2.86	0.583	0.067	0.28	0.09*	0.18
	PD models and frameworks	3.30	3.23	3.25	0.254	0.547	0.14	0.10	0.04

*p≤0.05
d≤0.4 small with little or no significant difference
0.5≤0.8 medium that tended towards practically significant difference
d≥0.8 large with practically significant difference

There was a significant effect of language of instruction (Afrikaans, English and other indigenous languages) on Building a SPI, F=3.38, p=0.036, where Mathematics teachers teaching in other indigenous languages were more conscious of who they were as a person, accepted the value of networking with their peers, wanted to develop their mathematical competencies, and adhered to the roles and responsibilities of the teaching profession than the Mathematics teachers who taught in Afrikaans (d=0.47, medium effect) (Table 5.12).

There was a significant effect of language of instruction (Afrikaans, English and other indigenous languages) on Teacher expectations for PD, F=4.87, p=0.008, where Mathematics teachers who taught in English were more explicit about what they required for PD than Mathematics teachers who taught in Afrikaans and other indigenous languages. However, these differences were not important in practice with small effects.

The results in Table 5.12 indicate that there were significant effects of language of instruction (Afrikaans, English and other indigenous languages) and teacher expectations for PD. The other elements of the TAS did not indicate significant differences with language of instruction.

5.4.1.4 Descriptive Statistics on Elements of Triangular Activity System and the Results of the Hierarchical Linear Modelling, Effect Sizes and Qualifications Differences

With this association the researcher measured whether the qualifications of the Mathematics teachers had an effect on the elements of TAS. Table 5.13 provides the results of hierarchical linear modelling for the qualifications and Table 5.14 provides effect sizes to test for differences in means of the elements of TAS and qualification (Addendum 5.5). Only the medium and large effect sizes were reported. The qualifications on the questionnaire were grouped as six levels for the analysis: (i) Diploma in Education (DE) III, (ii) Advanced Certificate in Education (ACE) or Higher Diploma in Education (HDE), (iii) Bachelor in Arts (BA) or Bachelor in Sciences (BSc), (iv) Bachelor in Education (BEd), (v) Master’s or Doctoral degree as post graduate qualification, and (vi) all other qualifications grouped as *other*.

Table 5.13 Descriptive statistics on Elements of Triangular Activity System and Results of Hierarchical Linear Modelling for Qualifications

Elements of TAS		Means						Estimate Residual	P values
		DE III	ACE	BEd	Post graduate	BA/BSc	Other		
Subject	Building a SPI	3.22	3.17	3.14	3.32	3.32	3.24	0.200	0.156
	TK	3.21	2.97	3.30	3.46	3.22	3.25	0.339	<0.000*
	TPACK	2.59	2.72	2.71	2.83	2.60	2.87	0.503	0.421
Tools	ICT for SPD	2.58	2.63	2.50	2.62	2.66	2.68	0.607	0.925
	Contributors to SPD	2.92	3.19	3.18	3.38	3.46	3.20	0.833	0.166
Rules	Teacher expectations for PD	3.23	3.13	3.18	3.18	3.30	3.16	0.301	0.517
Community	Policy Initiatives	3.07	3.28	3.43	3.23	3.04	3.45	0.849	0.172
	Responsibility to teaching and learning	2.92	3.27	3.35	3.20	3.28	3.15	0.959	0.646
Division of labour	Responsibility-management	2.71	2.85	2.95	2.91	3.04	2.92	0.592	0.578
	Responsibility of the DBE	2.90	3.40	3.30	3.24	3.20	3.24	1.458	0.678
	PD models and frameworks	3.21	3.19	3.25	3.34	3.38	3.11	0.249	0.077

*p≤0.05

Table 5.14 Effect Sizes to Test for Qualification Differences

Elements of TAS		DE III with ACE	DE III with BEd	DE III with Post	DE III with /BSc	DE III with other	ACE with BEd	ACE with Post	ACE with /BSc	ACE with other	BEd with Post	BEd with BA/BSc	BEd with other	Post with BA/BSc	Post with other
		Effect sizes (d-values)													
Subject	Building a SPI	0.11	0.18	0.22	0.22	0.04	0.07	0.34	0.34	0.16	0.40	0.40	0.22	0.00	0.18
	TK	0.41	0.15	0.43	0.02	0.07	0.57	0.84	0.43	0.48	0.27	0.14	0.09	0.41	0.36
	TPACK	0.18	0.17	0.34	0.01	0.39	0.01	0.16	0.17	0.21	0.17	0.16	0.23	0.32	0.06
Tools	ICT for SPD	0.06	0.10	0.05	0.10	0.13	0.17	0.01	0.04	0.06	0.15	0.21	0.23	0.05	0.08
	Contributors to SPD	0.30	0.28	0.50	0.59	0.31	0.01	0.21	0.30	0.01	0.22	0.31	0.02	0.09	0.20
Rules	Teacher expectations for PD	0.18	0.09	0.09	0.13	0.13	0.09	0.09	0.31	0.05	0.00	0.22	0.04	0.22	0.04
Community	Policy Initiatives	0.23	0.39	0.17	0.03	0.41	0.16	0.05	0.26	0.18	0.22	0.42	0.02	0.21	0.24
	Responsibility to teaching and learning	0.36	0.44	0.29	0.37	0.23	0.08	0.07	0.01	0.12	0.15	0.07	0.20	0.08	0.05
Division of labour	Responsibility of the DBE	0.18	0.31	0.26	0.43	0.27	0.13	0.08	0.25	0.09	0.05	0.12	0.04	0.17	0.01
	Responsibility of management	0.41	0.33	0.28	0.25	0.28	0.08	0.13	0.17	0.13	0.05	0.08	0.05	0.03	0.00
	PD models and frameworks	0.04	0.08	0.26	0.34	0.20	0.12	0.30	0.38	0.16	0.18	0.26	0.28	0.08	0.46

d≤0.4 small with little or no significant difference
0.5≤0.8 medium that tended towards practically significant difference
d≥0.8 large with practically significant difference

There was a significant effect of qualification (DE III, ACE, BA or BSc, BEd, post graduate degrees and other) on TK, F=0.48, p=<0.001 (Table 5.13). Mathematics teachers with post graduate degrees, BA/BSc DE III most frequently made use of social networks and regularly accessed the Internet for mathematical resources. A medium effect size (d=0.41) indicated a medium effect with practically significant differences between the TK of Mathematics teachers with a DE III qualification and Mathematics teachers with an ACE. A medium effect size (d=0. 43) indicated a tendency towards practically significant differences between the TK of Mathematics teachers with a DE III qualification and Mathematics teachers with an post graduate qualification. A medium effect size (d=0.57) indicated practically significant differences between the TK of Mathematics teachers with an ACE qualification and Mathematics teachers with BEd degree who indicated larger TK. There were significant differences between the TK of Mathematics teachers with an ACE and teachers with a post graduate qualification with effect size of d=0.84 which indicated a large effect with practically significant differences. A medium effect size (d=0.43), that tended towards practically significant differences between the TK of Mathematics teachers with an ACE qualification and Mathematics teachers with BA or BSc degree. The TK of Mathematics teachers with an ACE was lower than that of teachers with other qualifications, with effect size of d=0.48, which indicated a medium effect. A medium effect size (d=0.41) that tended towards practically significant differences between the TK of Mathematics teachers with a post graduate qualification and Mathematics teachers with BA or BSc degree (Table 5.14). The results from the above evidence show that Mathematics teachers with higher levels of qualifications were more competent to access social networking sites and download Mathematics resources from the Internet. The other elements did not show effect significant to be of importance in practice.

5.4.1.5 Descriptive Statistics on Elements of Triangular Activity System and the Results of the Hierarchical Linear Modelling, Effect Sizes and Subject Specialisation Differences

With this association the researcher measured whether the *subject specialisation* of the Mathematics teachers had an effect on the elements of TAS. None of the elements of the TAS showed significant differences with subject-specialisation (Addendum 5.5). Therefore subject-specialisation did not play a role during PD of Mathematics teachers.

5.4.1.6 Descriptive Statistics on Elements of Triangular Activity System and the Results of the Hierarchical Linear Modelling, Effect Sizes and Education District Differences

With this association the researcher measured whether the elements of TAS differed for *education districts*. The results of the hierarchical linear modelling and the effect sizes to test for education district differences between the Mathematics teachers who completed the questionnaire indicated that there were no significant differences regarding the elements of the TAS in the eight education districts (Addendum 5.5). Guidelines for the WCED proposed to be effective within all the EMDCs. This also indicated that the eight EMDCs in the WCED functioned within a generic hierarchical management structure by the PDE regarding provision of resources and support (Addendum 4.1).

5.4.1.7 Descriptive Statistics on Elements of Triangular Activity System and the Results of the Hierarchical Linear Modelling, Effect Sizes and Quintile Differences

With this association the researcher measured whether the quintile of a school had an effect on the elements of TAS (Addendum 5.5). Table 5.15 provides the descriptive statistics of the results of the hierarchical linear modelling and Table 5.16 indicates the effect sizes for quintile differences on the elements of TAS (next two pages).

There were significant differences between school quintiles and building a SPI, F=3.02, p=0.011(Table 5.15). The Mathematics teachers who taught at independent schools were more conscious of themselves and their developmental needs, embraced the concept of networking with their peers, required PD to improve their mathematical competencies, and adhered to the roles and responsibilities of the teaching profession than any of the quintile groups. Table 5.16 indicates the effect sizes for the differences between quintile groups for the elements of TAS. There were significant differences between building a SPI of Mathematics teachers at independent schools quintile 1 (d=0.77), quintile 2 (d=1.11), quintile 3 (d=0.95), quintile 4 (d=1.06) and quintile 5 schools (d=0.84) which indicated large practically significant differences.

There were significant differences for TPACK between school quintiles, F=2.91, p=0.014 (Table 5.15). The Mathematics teachers from the independent schools in the eight EMDCs had a deeper understanding of teaching Mathematics with technology and more frequently used ICT to transfer mathematical content to learners than any of the quintile schools, while quintile 2 schools had the lowest value. There were significant differences between the TPACK of Mathematics teachers at quintile 2 and quintile 1(d=0.80); quintile 3 (d=0.57); quintile 4 (d=0.53); quintile 5 (d=0.82) and independent schools (d=0.87), which indicated a medium or large effect with practically significant differences.

Table 5.15 Descriptive statistics on Elements of Triangular Activity System and Results of Hierarchical Linear Modelling for Quintiles Differences

Elements of TAS		Means						Estimate Residual	P values
		Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5	Independent		
Subject	Building a SPI	3.28	3.13	3.20	3.15	3.25	3.62	0.195	<0.011*
	TK	3.07	3.14	3.13	3.23	3.27	3.39	0.359	0.261
	TPACK	2.82	2.26	2.66	2.63	2.83	2.87	0.488	<0.014*
Tools	ICT for SPI	2.52	2.29	2.56	2.63	2.75	2.75	0.594	0.143
	Contributors to SPD	2.91	2.23	3.15	3.26	3.47	3.59	0.814	<0.011*
Rules	Teacher expectations for PD	3.37	3.07	3.14	3.17	3.13	3.56	0.289	<0.010*
Community	Policy Initiatives	3.22	2.89	3.24	3.14	3.39	3.45	0.854	0.241
	Responsibility to teaching and learning	3.05	2.70	3.21	3.30	3.83	3.52	0.932	0.320
Division of labour	Responsibility of management	2.88	2.62	2.82	2.88	3.06	3.04	0.586	0.165
	Responsibility of the DBE	2.95	2.90	3.27	3.07	3.51	3.96	1.398	<0.007*
	PD models and frameworks	3.30	3.16	3.21	3.27	3.26	3.43	0.253	0.630

*p≤0.05

Table 5.16 Effect Sizes for Quintiles

Elements of TAS		Effect sizes (d-values)														
		Quintile 1 with					Quintile 2 with				Quintile 3 with			Quintile 4 with		
		Quintile 2	Quintile 3	Quintile 4	Quintile 5	Independent	Quintile 3	Quintile 4	Quintile 5	Independent	Quintile 4	Quintile 5	Independent	Quintile 5	Independent	Quintile 5 with Independent
Subject	Building a SPI	0.34	0.18	0.29	0.07	0.77	0.16	0.05	0.27	1.11	0.11	0.11	0.95	0.23	1.06	0.84
	TK	0.12	0.10	0.27	0.33	0.53	0.02	0.15	0.22	0.42	0.17	0.23	0.43	0.07	0.27	0.20
	TPACK	0.80	0.23	0.27	0.01	0.07	0.57	0.53	0.82	0.87	0.04	0.24	0.30	0.29	0.34	0.06
Tools	ICT for SPD	0.30	0.05	0.14	0.30	0.30	0.35	0.44	0.60	0.60	0.09	0.25	0.25	0.16	0.16	0.00
	Contributors to SPD	0.75	0.27	0.39	0.62	0.75	1.02	1.14	1.37	1.51	0.12	0.35	0.49	0.23	0.37	0.13
Rules	Teacher expectations for PD	0.56	0.43	0.37	0.45	0.35	0.13	0.19	0.11	0.91	0.06	0.02	0.78	0.07	0.73	0.80
Community	Policy Initiatives	0.36	0.02	0.09	0.18	0.25	0.38	0.27	0.54	0.61	0.11	0.16	0.23	0.27	0.34	0.06
	Responsibility to teaching and learning	0.36	0.17	0.26	0.81	0.49	0.53	0.62	1.17	0.85	0.09	0.64	0.32	0.55	0.23	0.32
Division of labour	Responsibility-management	0.34	0.08	0.00	0.24	0.21	0.26	0.34	0.57	0.55	0.08	0.31	0.29	0.24	0.21	0.03
	Responsibility of the DBE	0.04	0.27	0.10	0.47	0.85	0.31	0.14	0.52	0.90	0.17	0.20	0.58	0.37	0.75	0.38
	PD models and frameworks	0.28	0.18	0.06	0.08	0.26	0.10	0.22	0.20	0.54	0.12	0.10	0.44	0.02	0.32	0.34

d≤0.4 small with little or no significant difference
0.5≤0.8 medium that tended towards practically significant difference
d≥0.8 large with practically significant difference

There were significant differences between school quintiles and contributors of SPD, F=3.05, p=0.011 (Table 5.15). The Mathematics teachers who taught at independent schools had highest acknowledged the importance of ICT policy structures to be in place so that Mathematics teachers could adhere to their role and responsibilities for Phase III implementation of the e-Education policy. Quintile 2 schools had lowest scores which differed significantly from quintile 1(d=0.75); quintile 3 (d=1.02); quintile 4 (d=1.14); quintile 5 (d=1.37) and independent schools (d=1.51), which indicated large effect with practically significant differences. Quintile 2 schools also scored significantly lower than quintile 5 schools with effect size of d=0.62, and independent schools (d=0.75) which indicated a medium and large effect indicating practically significant differences. Quintile 3 schools also scored significantly lower than independent schools (d=0.49) that tends towards practically significant differences between Mathematics teachers at quintile 3 and independent schools regarding contributors to SPD (Table 5.16).

There was significant differences between school quintiles and teacher expectations for PD, F=3.06, p=0.010 (Table 5.15). The Mathematics teachers who taught at independent schools scored practical significantly higher than quintile 2 (d=0.91); quintile 3 (d=0.78); quintile 4 (d=0.73) and quintile 5 schools (d=0.80) to be part of the PD planning process to attend contextualised subject-specific training based on their own needs with clear guidelines for the integration of ICT in Mathematics teaching and learning. There were significant differences between teacher expectations at quintile 1 and quintile 2 (d=0.56); quintile 3 (d=0.43) and quintile 5 schools (d=0.45) with medium effect sizes tends towards practically significant differences (Table 5.16).

There was significant differences between school quintiles and responsibility of DBE, F=3.30, p=0.007 (Table 5.15). Even though the Mathematics teachers from the independent schools were not dependent on the DBE for the provision of ICT resources, funding to equip schools with the ICTs to deliver teaching and learning, and PD they felt strongest about the DBE's responsibility. There were significant differences between what Mathematics teachers' view as the responsibility of DBE at independent schools and quintile 1 (d=0.85), quintile 2 (d=0.90), quintile 3 (d=0.58), and quintile 4 schools (d=0.756), which indicated a medium or large effect with practically significant differences. Quintile 1 also had a lower score than quintile 5 schools (d=0.47) which tends towards a practically significant difference (Table 5.16).

5.4.1.8 Descriptive Statistics on Elements of Triangular Activity System and the Results of the Hierarchical Linear Modelling, Effect Sizes and Type of School Differences

With this association the researcher measured whether the *type of school* had an effect on the elements of TAS (Addendum 5.5). Table 5.17 provides the results of hierarchical linear modelling and Table 5.18 provides the effect sizes to test for type of school and differences on the elements of TAS (next two pages).

Table 5.17 Descriptive statistics on Elements of the Triangular Activity System and the Results of Hierarchical Linear Modelling for Type of School

Elements of TAS		Means					Estimate Residual	P values
		Farm	Semi-urban	Urban	Former Model C	Independent		
Subject	Building a SPI	3.21	3.19	3.26	3.22	3.40	0.203	0.464
	TK	3.10	3.12	3.21	3.29	3.22	0.362	0.401
	TPACK	2.77	2.75	2.61	2.79	2.66	0.504	0.504
Tools	ICT for SPD	2.56	2.57	2.58	2.74	2.66	0.602	0.603
	Contributors to SPD	2.92	3.18	3.11	3.60	3.31	0.807	<0.003*
Rules	Teacher expectations for PD	3.23	3.23	3.22	3.09	3.28	0.300	0.397
Community	Policy Initiatives	3.21	3.22	3.16	3.46	2.90	0.848	0.139
	Responsibility to teaching and learning	3.08	3.20	3.00	3.53	3.48	0.925	<0.010*
Division of labour	Responsibility of management	2.94	2.92	2.74	3.14	2.91	0.575	<0.024*
	Responsibility of the DBE	2.97	3.19	2.98	3.67	3.51	1.393	<0.004*
	PD models and frameworks	3.25	3.29	3.25	3.23	3.27	0.256	0.959

*p≤0.05

Table 5.18 Effect Sizes for Type of School

Elements of TAS		Effect sizes (d-values)									
		Farm with			Semi-urban with				Urban with		Model C with
		Semi-urban	Urban	Model C	Independent	Urban	Model C	Independent	Model C	Independent	Independent
Subject	Building a SPI	0.04	0.11	0.02	0.42	0.16	0.07	0.47	0.09	0.31	0.40
	TK	0.03	0.18	0.32	0.20	0.15	0.28	0.17	0.13	0.02	0.12
	TPACK	0.03	0.23	0.03	0.15	0.20	0.06	0.13	0.25	0.07	0.18
Tools	ICT for SPD	0.01	0.03	0.23	0.13	0.01	0.22	0.12	0.21	0.10	0.10
	Contributors to SPD	0.29	0.21	0.76	0.43	0.08	0.47	0.14	0.55	0.22	0.32
Rules	Teacher expectations for PD	0.00	0.02	0.26	0.09	0.02	0.26	0.09	0.24	0.11	0.35
Community	Policy Initiatives	0.01	0.05	0.27	0.34	0.07	0.26	0.35	0.33	0.28	0.61
	Responsibility to teaching and learning	0.12	0.08	0.47	0.42	0.21	0.34	0.29	0.55	0.50	0.05
Division of labour	Responsibility-management	0.03	0.26	0.26	0.04	0.24	0.29	0.01	0.53	0.22	0.30
	Responsibility of the DBE	0.19	0.01	0.59	0.46	0.18	0.41	0.27	0.58	0.45	0.14
	PD models and frameworks	0.08	0.00	0.04	0.04	0.08	0.12	0.04	0.04	0.04	0.08

d≤0.4 small with little or no significant difference
0.5≤0.8 medium that tended towards practically significant difference
d≥0.8 large with practically significant difference

Table 5.17 indicates the descriptive statistics on elements of TAS for different types of schools and Table 5.18 provided the effect sizes to test for type of school differences between the Mathematics teachers who completed the questionnaire. The medium and large effect sizes were reported for this analysis (Addendum 5.6).

There were significant differences between type of school and contributors of SPD, F=4.107, p=0.003 (Table 5.17). The Mathematics teachers from former Model C schools had a significantly higher score to recognized the value of ICT policy structures to be in place so that Mathematics teachers could adhere to their role and responsibilities for Phase III implementation of the e-Education policy than farm schools (d=0.76); semi-urban schools (d=0.47) and urban schools (d=0.55), which indicated a medium or large effect with practically significant differences. There were also significant differences between contributors of SPD of Mathematics teachers at farm schools and independent schools with effect size of d=0.43 which indicated a medium effect which indicated a tendency to a practically significant difference (Table 5.18). These differences confirmed how the socio-economic circumstances of the schools have an influence on their priorities. Many former Model C teachers encountered challenges different from those teachers from farm and semi-urban areas. At former Model C schools Mathematics teachers teach under better circumstances, but are pressured by the parents and the SMT, and in farm and semi-urban areas Mathematics teachers are confronted with conditions of poverty, a shortage of social and economic development, and limited chances for future development (Gardiner, 2008).

There were significant differences between type of school and responsibility to teaching and learning, F=3.36, p=0.010 (Table 5.17). The Mathematics teachers from former Model C schools had a significantly higher score to regarded an ICT strategic plan as important for future PD than farm schools (d=0.47); and urban schools (d=0.55), which indicated a medium effect with tendency to practically significant differences. Urban schools and farm schools also had a significantly lower score than independent schools (d=0.50), while farm schools had a significantly lower score than independent schools (d=0.42 and 0.50 respectively), that tended towards a practically significant difference (Table 5.18).

There were significant differences between type of school and responsibility to management, F=2.85, p=0.024(Table 5.17). The Mathematics teachers from former Model C schools had a significantly higher score (d=0.53) and regarded the responsibility of management as more important than urban schools which indicated a medium effect with tendency to practically significant differences (Table 5.18).

There were significant differences between type of school and responsibility of DBE, F=4.00, p=0.004 (Table 5.17). Former Model C schools had a significantly higher score (d=0.59) and regarded the responsibility of the DBE as more important than farm schools, semi-urban schools (d=0.41), and urban schools (d=0.58) which indicated a medium effect with tendency to practically significant differences (Table 5.18). Semi-urban and urban schools had a significantly lower score than independent schools (d=0.46 and 0.45 respectively), that tended towards a practically significant difference (Table 5.18).

5.4.2 Elements of Triangular Activity System and Results of Hierarchical Linear Modelling

Items A2, A3, A4, B6, B11, B13, and B14 from Part A and Part B (Addendum 4.11) of the questionnaire were correlated with the extracted factors to see whether there were associations between the elements of TAS and these biographical information of the Mathematics teachers in their teaching and learning context. These differences were conducted using SAS (SAS Institute Inc, 2011) (Addenda 5.6-5.8).

The effect sizes were measured by Spearman rank order differences to measure the degree of association between two ordinal variables of which the R^2 indicators related to: 0.01=a poor fit; 0.1=a moderate fit; and 0.25=a strong fit (Cohen et al., 2011:701). Only the medium and large differences were reported as they were of importance in practice. There was a medium significant association between age and the responsibility of the DBE with $R^2=0.11$ which indicated that older teachers scored higher on responsibility of the DBE (Table 5.19 next page). There were no other significant associations between number of years teaching, number of years teaching Mathematics in the respective grades, number of computers available for teaching and learning, Mathematics teachers' computer literacy level, and the learners' computer literacy level with the elements of the TAS.

From the above results it was clear that overall the DBE, PDE and schools played an important role for the integration of ICT and that the Mathematics teachers were aware of their requirements for future PD. In general teachers from English and independent schools were more aware of their SPI and were more assertive to voice their opinions regarding PD, the responsibility of the DBE and the school management.

Table 5.19 Hierarchical Linear Modelling for Biographical Information

Biographical Information	R^2										
	Subject			Tools		Rules	Community		Division of labour		
	Building a SPI	TK	TPACK	ICT for SPD	Contributors to SPD	Teacher expectations for PD	Responsibility to Teaching and Learning	Policy Initiatives	Responsibility DBE	Responsibility management	PD Models and Frameworks
Age	0.010	0.033	0.006	0.004	0.027	0.025	0.027	0.023	0.110	0.011	0.012
Number of years teaching	0.012	0.037	0.010	0.007	0.027	0.027	0.020	0.013	0.006	0.008	0.014
Number of learners at school	0.000	0.010	0.010	0.010	0.000	0.004	0.001	0.000	0.001	0.004	0.004
Number of years teaching Mathematics for Grade 7	0.001	0.001	0.007	0.010	0.003	0.000	0.002	0.010	0.005	0.003	0.003
Number of years teaching Mathematics for Grade 8	0.007	0.023	0.000	0.000	0.000	0.022	0.000	0.010	0.003	0.000	0.010
Number of years teaching Mathematics for Grade 9	0.009	0.027	0.001	0.001	0.000	0.022	0.001	0.007	0.003	0.001	0.010
Number of computers available for teaching Mathematics in Grade 7	0.010	0.001	0.019	0.011	0.000	0.000	0.001	0.002	0.001	0.010	0.003
Number of computers available for teaching Mathematics in Grade 8	0.000	0.022	0.017	0.013	0.022	0.001	0.040	0.000	0.001	0.044	0.007
Number of computers available for teaching Mathematics in Grade 9	0.004	0.018	0.004	0.004	0.023	0.004	0.026	0.000	0.002	0.020	0.000
Mathematics teachers' computer literacy level	0.024	0.047	0.011	0.016	0.046	0.005	0.000	0.000	0.000	0.000	0.022
Learners' computer literacy level in Grade 7	0.002	0.000	0.032	0.020	0.004	0.005	0.003	0.023	0.002	0.016	0.003
Learners' computer literacy level in Grade 8	0.004	0.003	0.009	0.005	0.016	0.004	0.008	0.000	0.001	0.002	0.001
Learners' computer literacy level in Grade 9	0.000	0.005	0.007	0.001	0.006	0.010	0.007	0.010	0.000	0.005	0.000

5.5 Summary of the Chapter

Chapter Five modelled the results of the survey which were distributed amongst 300 Mathematics teachers in eight EMDCs in the WCED. Three types of analyses were conducted and described in this chapter: descriptive statistics of the biographical information, inferential statistics (principal axis factor analysis) of Parts D, E, and F of the questionnaire, and hierarchical linear modelling with the extracted elements from the inferential statistics and the biographical information. Chapter Six provides an overview of the research, gives a synopsis of the adjustable and radical exploration phases of the research, validate the adjustable and radical explorations phases through SEM, and maps the guidelines for the PD of Mathematics teachers in the pedagogical use of ICT in ODL. Additionally Chapter Six makes future research recommendations and reflects on the research journey through a complex landscape.