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The adjustment of first year female engineering students into university: an evaluation

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Chapter 1 Introduction

1.1 Overview

This study forms part of a series of studies conducted over a twenty year period by Potter and his colleagues (Potter, Meyer, Scott and da Silva, 1984; Potter, 1991; Potter & Van der Merwe, 1993; 1994; 2001; Potter, Van der Merwe & Kaufman, 2003; Potter, Van der Merwe, Kaufman & Delacour, 2006) on the relationship between academic performance in first year Engineering graphics, and cognitive, personality and social factors. In addition, this study builds on the previous work of Kaufman (2003) on factors that influenced the academic performance of female Engineering students in Engineering graphics at the University of the Witwatersrand. Kaufman (2003) found that female Engineering students were at a disadvantage owing to the fact that they had not taken technical drawing at school level, and were thus in need of academic support in Engineering graphics at entry point to the university.

1.2 Focuses of this Research

There has been a long tradition of research into the relationship between three dimensional spatial ability and academic performance in university courses in which Engineering graphics is taught. The long term findings have over the years demonstrated that three dimensional spatial ability is not only a consistently firm predictor of academic performance in first year university Engineering graphics courses, but also has the strongest predictive relationship with success in both engineering drawing, as well as in its applications in engineering design (Behr, 1982; Deregowski, 1977; Mauvis, 1979; Taylor, 1980; 1981; Visser, 1981; Potter, Van der Merwe & Kaufman, 2003; Potter, Van der Merwe, Kaufman & Delacour, 2006).

One of the objectives of this study is to determine whether first year female Engineering students have more poorly developed two and three dimensional spatial abilities than male engineering students. Secondly, the research also attempts to establish whether difficulties with three dimensional spatial perception play a role in the academic performance of first year female Engineering students, and whether their male counterparts have similar difficulties. In addition, the study looks into whether the coping methods used by first year female Engineering students are similar to those employed by their male counterparts.

1.3 Rationale

This research forms part of a longitudinal investigation into the difficulties of students with first year Engineering graphics (Potter, 1984; Van der Merwe, 1983 & Kaufman, 2000). Previous studies carried out at the University of the Witwatersrand over the past twenty years have established a consistent relationship between spatial ability (and in particular three dimensional spatial perception) and the academic performance of first year Engineering graphics students (Taylor, 1978; 1981; Potter, Van der Merwe & Kaufman, 2003; Potter, Van der Merwe, Kaufman & Delacour, 2006). These studies done at Wits for the past twenty years have also established that engineering students have better developed three dimensional spatial abilities than other university students studying science degrees (Potter, 1991; Potter, Van der Merwe and Kaufman, 2003).

In these previous studies as well as in existing literature at other universities in South Africa (Behr, 1982; Mauvis, 1979; Millroy & Rochford, 1985), there has been little focus on the three dimensional spatial abilities of female Engineering students, despite evidence that few female students take technical drawing at school level (Kaufman, 2003), and international literature which indicates that training can eliminate cognitive differences between women and men (Azar, 2008).

The international literature has focused on the academic performance of female students in mathematics, science and technology, but there is very little literature on the academic performance of female students in Engineering graphics. It has been reported, for example, that female students tend to do badly in mathematics and science courses (Steele & Aronson, 1995), as well as in courses in engineering and technology (Steele & Aronson, 1995). Potter, Van der Merwe and Kemp (1984; 1987) have reported that three dimensional spatial ability can be improved with appropriate instruction. Van der Merwe and Potter (2000) have also published materials which aim to improve visualisation abilities. Kaufman (2001; 2003) reported that students who used these materials reported improved performance in Engineering graphics.

Potter, Van der Merwe, Kaufman and Delacour (2006) reported an association between teaching techniques aimed at improving visualisation ability, improvements in three dimensional spatial perception and increased pass rates in Engineering graphics. High pass rates were reported for all students taking Engineering graphics, including those from previously disadvantaged backgrounds. These authors also reported that female students experienced difficulties with the Engineering graphics course, and recommended that gender issues be explored in more depth in future studies.

This study attempts to fill this gap. The main focus of the current research is on discovering how female students cope with the transition from school to university, and whether spatial ability plays a role in their academic performance in Engineering graphics. The study focuses in particular on the adaptation as well as coping methods of female students in a first year Engineering graphics course. These are compared with those used by their male counterparts taking the course.

1.4 Aims and Operationalisation of the Study

This study has three aims:

- To establish if three dimensional spatial perception ability plays a role in females' academic performance in the first year Engineering graphics course. This aim will be operationalised by testing both the two and three dimensional spatial perception of first year Engineering students, and comparing these abilities in male and female students.
- To find out how female students make the adaptation to university and the coping mechanisms they adopt in doing so. This aim will operationalised by interviewing female students taking the first year Engineering graphics course.
- To compare the coping methods adopted by female students with those used by their male counterparts. This aim will operationalised by interviewing male students taking the first year Engineering graphics course, and comparing the self-reports of the male and female students.

1.5 Research Questions

Within the above operationalisation, this study attempts to answer two broad evaluative questions:

- A. How do female Engineering students cope with their studies?
- B. Is three dimensional spatial perception (ability) an influence on how female Engineering students cope with their studies?

To answer these questions, both quantitative and qualitative analyses will be conducted. The quantitative analyses will address the following questions using the following statistical procedures:

- Is there a relationship between both two dimensional spatial ability and three dimensional spatial perception and the academic performance of all first year students in Engineering graphics? (correlation & backward stepwise regression)

- Does the relationship between both two dimensional spatial ability and three dimensional spatial perception and academic performance differ in the case of male and female Engineering students? (Fisher's Z test)
- Is the academic performance of male and female engineering students different? (Two independent sample t -Test)
- Are there different relationships between gender, group, two dimensional spatial perception, three dimensional spatial perception and academic performance in students who are receiving special tuition for their difficulties, as compared to the relationships between these variables and academic performance of other students in first year Engineering Graphics? (ANCOVA)

The qualitative analyses will address the following questions through content analysis of interview data:

- What strategies are used by female Engineering students in making the transition from school to university?
- Are similar strategies effective in studying all first year Engineering subjects, or are different strategies necessary in studying Engineering graphics?
- Do male Engineering students use similar strategies to female students in coping with the demands of their first year courses?
- What coping strategies are necessary for female Engineering students who have poorly developed three dimensional spatial ability as opposed to well developed three dimensional spatial ability?
- Are these strategies similar to those adopted by male Engineering students with poorly developed three dimensional spatial ability as opposed to well developed three dimensional spatial ability?
- Are there other influences on the students' academic performance, and are they similar for males and females, as well as for students receiving special tuition for their difficulties, versus those in the mainstream programme?

1.6 Summary

This chapter has presented the focuses of this study, which focus on the relationship between spatial ability and the academic performance of first year female Engineering students. The study is multimethod, and is based on both quantitative and qualitative analyses.

On a quantitative level, the study aims to establish the spatial ability of first year Engineering students through the administration of two tests namely the F (two dimensional) and the H (three dimensional) tests of spatial ability. The study then explores the relationship between spatial ability and academic performance in first year female Engineering students. This is done through analysis of the relationship between spatial ability and academic performance in Engineering graphics.

On a qualitative level, the study aims to establish the study methods adopted by female Engineering students using interviews. These are conducted with 18 first year female Engineering students. A contrast group of 18 first year male Engineering students are also interviewed to determine whether the study methods adopted by first year female Engineering students were similar to those used by male Engineering students, and whether they both used the same methods to enable them to make the transition from school to first year Engineering studies at university.

The study builds on previous studies conducted in the Engineering Faculty over a twenty year period. It fills a gap in knowledge concerning the study methods adopted by female as opposed to male Engineering students, and the role played by three dimensional spatial perception as well as other spatial abilities in enabling female Engineering students to successfully make the transition from school to university.

1.7 Glossary of Terms

Spatial Ability/Perception: There are many definitions of spatial ability. According to Sternberg (1990), one's spatial ability refers to the visualisation of shapes, rotation of objects, and how pieces of a puzzle would fit together. Yet another definition is that "spatial ability concerns the ability to perceive visual or spatial ability information, to transform and modify this information and to recreate visual images even without reference to an original physical stimulus" (Gardener, Kornhaber & Wake, 1996: 207). In this study, the term spatial ability is used include the use of both mental imagery and spatial visualization in Engineering Drawing and Design (Potter and Van der Merwe, 2001).

Mental Imagery

Mental imagery is defined as the mental representation of things such as settings, events, and objects which are not currently being seen sensed by the sense organs (Sternberg, 1990).

Spatial Visualisation

Spatial visualisation refers to the ability to rotate two and three dimensional objects pictorially represented (Delacour, 2004).

Academic Performance

Taylor (1978) asserted that academic performance of first year Engineering students could be determined through their success in scholastic assessment particularly in mathematics and physics. Research has also revealed that there exists a relationship between success and intelligence. It has also been found out that three dimensional spatial ability psychometric tests were good predictors of first year Engineering students' academic performance (Taylor, 1978; 1980; Potter, 1991). Academic performance is defined as grades obtained by students in their courses. For purposes of this research, academic performance will be defined as the grades obtained by students in their June

examination marks for Engineering Graphics. This is thus a specific operational definition developed for purposes of this study.

Engineering Graphics

Engineering graphics is a one year full time compulsory course taught to all disciplines of Engineering students during their first year of study (Potter & Van Der Merwe, 2000).

Aptitudes: Spatial ability is a form of aptitude. Aptitudes are specific abilities utilised in certain areas of achievement (Berk, 2003) such as three dimensional spatial ability being used in Engineering or in architecture. Aptitudes are formed through the interaction between psychological factors such as motivation and the experiences encountered by an individual on a daily basis. Aptitudes are therefore believed to be acquired over time(Berk, 2003; Cohen & Swerdlik, 2003).

Two Dimensional Spatial Ability

This is defined as the ability to visualise and rotate objects that are only shown in two dimensions such as top, front and right side (Olkun, 2003). In this study this definition is operationalised through the F test, which is part of the differential aptitude test which assesses individual potential across eight different ability areas. The F test is comprised of forty-nine items which require participants to figure out from a variety of alternatives the correct two dimensional representation of a model (Potter, 1991; Taylor, 1980).

Three Dimensional Spatial Ability

This is defined as the ability to visualise and rotate objects that are shown in three dimensions and are perspective in nature (Olkun, 2003). three dimensional spatial perception is considered to be a higher level cognitive ability than two dimensional spatial perception (Ho, Eastman, & Catrambone, 2006). In this study this definition is operationalised through the H test, which is part of the differential aptitude test which assesses individual potential across eight different ability areas. The H test is comprised of forty items. Each item consists of four three dimensional diagrams. The students are

required to depict which of these representations would be correct if they were folded to form a three dimensional model.

Stereotype Threat: Stereotype threat refers to the state of being at risk of confirming as self-characteristic, a negative stereotype about one's group (Steel & Aronson, 1995).

Self-Efficacy: The concept of self-efficacy refers to one's expectations or beliefs about their ability to successfully perform a given task (Hackett & Betz, 1981).

Chapter 2: Background to and Context of this Study

2.1 The Context of the Study

Spatial skills such as spatial visualisation and mental rotation are important abilities in tertiary education. A number of studies have shown that these skills underpin spatial and visual thinking in Engineering, computer graphics, architectural and other scientific courses (Field, 2007). Investigation of how these cognitive skills develop among undergraduates is thus important to understanding how students succeed in their tertiary level courses, as well as to assist students who may lack these abilities.

This study is based on the findings of previous research at the University of the Witwatersrand on the academic performance of Engineering students and the high failure rate in the late 1970s. An initial study carried out by Taylor (1978), revealed that scholastic achievement was the best predictor of academic success as well as a positive relationship between intelligence and success. Taylor (1978) also found out that biographical information, such as school type and parents education for example, correlated considerably with academic success. Guided by his findings, Taylor (1978) cautioned institutes of advanced education against selecting applicants based upon their historical background. He suggested that they rather focus on the applicant's existent abilities, for fear of further perpetuating socio-economic differences (Taylor, 1978).

To date very few studies have been conducted on how spatial skills develop in female undergraduate students (Quaiser-Pohl and Lehmann (2002). This research attempts to fill an evident gap in existing literature in this area.

2.2 Potter and Van der Merwe's work

Potter and Van der Merwe (Potter & Van der Merwe 1982; 1983; 1992; 1995; Van der Merwe & Potter, 2000) have carried out a number of longitudinal studies on engineering students at the University of the Witwatersrand for a period of over twenty years. These studies have been aimed at improving pass rates in a compulsory first year course in

Engineering Graphics (involving engineering drawing, design and analysis), as well as developing teaching approaches aimed at increasing student pass rates in the course (Potter & Van der Merwe 1982; 1983; 1992; 1995; Van der Merwe & Potter, 2000).

In their research, Potter and Van der Merwe (Potter & Van der Merwe 1982; 1983; 1992; 1995; Van der Merwe & Potter, 2000) have also compared the development of spatial ability both within and between groups of engineering students as well as between groups of engineering and science students. Their studies have been longitudinal and ongoing, and this study has been conducted as part of this research programme.

To date, Potter and Van der Merwe's findings suggest that students vary in spatial ability and that students with low scores on tests of three dimensional spatial perception are at risk as regards passing the first year Engineering Graphics course. They have also reported that that students with low scores on tests of three dimensional spatial perception can be trained to use mental imagery, but may require extended exposure to exercises involving modelling and sketching and exercises which link three dimensional models to different views used in multiview sketching and drawing.

Potter and Van der Merwe have also attempted to find out if three dimensional spatial perception increases after instruction in different forms of mental imagery and three dimensional representation, and their combined use in visualisation. Their results have indicated that both three dimensional spatial perception and academic performance improve in response to instructional techniques designed to improve spatial ability. The level of three dimensional spatial perception at the time of university intake has also emerged as an important influence on academic performance in engineering graphics (Potter & Van der Merwe 1982; 1983; 1992; 1995; Van der Merwe & Potter, 2000).

In a study linked to Potter and Van der Merwe's research programme, Kaufman (2000) did a study on students' perceptions of the role of mental imagery in academic performance in engineering graphics. Her findings indicated that a number of factors

were influential in terms of academic performance in the first year Engineering Graphics course. The students in Kaufman's sample reported that mental imagery was an important aspect when drawing three-dimensional sketches and many felt that their inability to form these images affected their academic performance in the first year Engineering Graphics course.

Other variables were also found to be influential in terms of the students' academic performance in the first year Engineering Graphics course. These were identified as previous experience, cross-cultural differences and gender issues from the content categories (Kaufman, 2000). Kaufman particularly focused on gender as many of the female students reported that they had major difficulties with the graphics course as a whole. In addition, previous research studies into the experiences and participation of females in engineering revealed that a number of social factors were related to self-concept and lack of confidence, lack of encouragement and role models within the field, isolation and loneliness, "being less female" (Royer, 1995) and gender discrimination.

Also linked to Potter and Van der Merwe's research programme, Delacour (2004) carried out a study on changes in the spatial ability of engineering students through the period of 1982-2001. Her study investigated whether the three dimensional spatial perceptual abilities of first year engineering students at the University of the Witwatersrand changed over a twenty year period. She examined scores on a test of three dimensional spatial perception administered at the time of university intake and after six months of instruction in the first year Engineering Graphics course. She also investigated whether gains in three dimensional spatial perception were made after six months of instruction in the first year Engineering Graphics course in the years 2000 and 2001. Finally Delacour set out to determine whether three dimensional spatial perception was a consistent predictor of academic performance in first year Engineering Graphics course over the years of 1982, 1983, 1992, 2000 and 2001 (Delacour, 2004).

Delacour's findings were that differences occurred from year to year and that gains made in the early 1980's had been the largest. Her data also indicated that there was a

significant decline in the scores of students in the year 2000, and concluded that this had been due to an atypical student intake in that year. She also concluded that the spatial ability of students had changed over the past twenty years and that there had been a distinct deterioration of the effects of the intervention (teaching in the first year Engineering Graphics course) in terms of gains made by the students in three dimensional spatial perception, which still had a strong relationship as a variable with student performance in the course (Delacour, 2004).

A third study linked to Potter and Van der Merwe's research programme was a study by Kaufman (2003), which focused on the experiences of female engineering students and their study strategies, with particular focus on three dimensional spatial perception as a predictor of academic performance in the first year Engineering Graphics course. Kaufman reported that all the female students in her sample experienced difficulties with engineering graphics as a subject. To cope with the course, the students worked with other students, and learned in this way how to work on the types of exercises they were required to complete for course credit.

However, while it was clear from Kaufman's study that all female students had difficulties with the course content, her study did not focus on whether female engineering students had poorly developed three dimensional spatial perception. Nor did she focus on how female engineering students coped with the transition from school to university, and whether three dimensional spatial perception affected their ability to make this transition. The above mentioned factors form the departure points, and will be the focuses of the present study.

2.3 Historical Overview of Education in South Africa

In the 1990s, more than 64% of the Black population was functionally illiterate and 60% of those under 30 years of age in South Africa were not engaged in formal education. In addition, in South Africa's past, women of all races were barred from achieving their full economic potential due to both legislative and non-legislative discrimination.

One of the effects of lack of educational opportunity is that very few women hold senior positions in industry, especially in technology related positions. Presently, approximately 20% of women work in technological industries, which is of great concern (James, Smith, Roodt, Primo & Evans, 2006; Audrey, Prins & Vijay, 1997). One of the reasons is that South Africa has a shortage of engineers (Swartz & Foley, 1996; Thomas, 1996), and in this context 20% is a small proportion. It is not surprising that a strategic decision has been taken by government to prioritise spending on education. This is because it is believed that better education enables participation in democratic process, further education and the country's economic growth (Swartz & Foley, 1996; Thomas, 1996).

There are also indications from the literature that few Black students who managed to enter university were often channeled into areas such as social work and religious studies (Swartz & Foley, 1996). Apartheid in higher education has created a huge discrepancy between numbers of Black and White graduates. The vast majority of those receiving technical education were predominantly White male students during apartheid (Potter, 1995; Cole, 1994).The departments of Science and Technology, Engineering and Mathematics are characterised by gender imbalances, especially as students move into tertiary education (Hall, Davis, Bolen, China, 1999).

In a study of girls' and boys' mathematical performance in primary school, Hall et al.,(1999) did not find significant differences in mathematical achievement between boys and girls from primary through junior high school. They did, however, report a steady upward trend for girls to outperform girls from high school through tertiary. Hall et. al., (1999) suggested that although young women seemed to have narrowed the gender gap in terms of taking Mathematics and Science courses, they still lagged behind men in taking more advanced mathematics and Engineering courses.

Jawitz, Case and Tshabalala (2000) conducted a study on why females did not study Engineering. They used a sample of first year students from the University of Cape Town and found that the problem lied in the pool of students available for Engineering studies. In 1999 there were 438 female students who had C symbols for higher grade mathematics and Physical Science, and only 11% were registered for Engineering. This indicates that

there are few females from high school into university who study Engineering, and the number is even smaller for black females (Jawitz et al., 2000). Other studies have shown that the few women who enroll for Engineering seem to be achieving low scores as compared to their male counterparts (Martineau, 1997). Evidence from a variety of sources supports the notion that females perform better in verbal abilities than males. Males on the other hand, perform better in spatial ability courses like physics and chemistry (Halpern, 1986; Baenniger & Newcombe, 1989).

The literature has focused in particular on the development of spatial abilities (Potter, 1991; Potter, Van der Merwe & Kemp, 1984; 1987). In this study, theories that will be used to explain the development of cognitive abilities with focus on spatial abilities are Piaget's theory of perception and imagery, Feuerstein's notion of Mediated Learning, and Vigotsky's theory of cognitive development (Cockroft, 2002). The stereotype threat theory and the self efficacy career theory have also been used to explain the reasons behind the low scores of females in Engineering (Steel, 1991; Stead & Watson, 1996).

2.4 Gender Differences in Spatial Ability

Spatial ability is defined as "the ability to imagine what an irregular figure would be like if it were rotated in space or an ability to discern the relationship among shapes and objects" (Halpern, 1986:48). The ability to utilise spatial abilities is very important to human life. It is used intensively in architecture, chemistry, building and Engineering, which will be the focus of the study (Halpern, 1986:48).

One enduring finding of cognitive psychology is that boys and men consistently outperform girls and women on certain standard measures of spatial ability (Halpern, 1992; Lynn & Peterson, 1985). However, a number of researchers have reported that training can help women improve their scores on tests of mental rotation and other spatial tasks (Baenger & Newcombe, 1989; Webley 1987; Maccoby & Jacklin, 1974; Voyer, Voyer, & Bryden, 1995). Some studies suggest that in some cases, the training can actually eliminate the difference between women and men. It is also believed that if such

techniques are used to teach young girls, the gender difference may someday disappear (Azar, 2008; Feingold, 1988; Alington, Leaf & Monaghan, 1992).

2.5 Implications of the Current Study

In the South African context, in which African students until recently were not allowed by legislation to register for first year engineering courses at the best universities in the country, three dimensional spatial perception has had major implications. It was established at the University of the Witwatersrand in the early 1980's (Taylor, 1980; 1981; Visser, 1981) that many students entered university with low levels of three dimensional spatial perception, and were at risk with respect to passing Engineering graphics courses at the university. This was particularly the case where African students were concerned (Potter, van der Merwe and kemp, 1984; 1987).

It was also established over this period of the 1980's (Potter, Van der Merwe and Kemp, 1984; 1987) that three dimensional spatial perception was trainable. This finding enabled teaching materials to be developed. which have been used as the basis for teaching engineering graphics at the university over the past twenty years.

It has been established in recent years, however, that female engineering students are at risk with respect to making the transition from school to university (Kaufman, 2003), for the reason that they do not take engineering drawing courses at school level. Many female engineering students thus enter university disadvantaged and more poorly prepared for the demands of first year university than their male counterparts (Potter, Van der Merwe and Kaufman, 2003).

This study focuses on how female students make the transition to university, and on the role three dimensional spatial perception plays in hampering or hindering their progress. The implications of this study are to highlight the importance of the role played by this cognitive factor in the success of female engineering students at university.

Chapter 3 Literature Review

3.1 Piaget's Theories of Perception and Imagery

Piaget has proposed that the development of intellectual and cognitive abilities in children follow a series of stages from infancy to adolesence (Nakin, 2003) Piaget identifies four periods, namely the sensori-motor period, preoperations, concrete operations and formal operations stage (Piaget, 1971; Nakin, 2003).

Piaget and Inhelder (1971) investigated age related differences in spatial ability suggesting that an individual's cognitive development determined the potential of what one could achieve. At the initial stage (sensori-motor) the children in their samples exhibited a purely egocentric view of the world that continued to the second stage. At the third stage, the children could perform reversible mental actions but only on real, concrete objects (Cockroft, 2002). During the final stage of formal operations children not only classified, ordered and reversed mental operations, but could also take results of these concrete operations and generate hypotheses about their logical relations, resembling the kind of thinking called 'scientific method' and referred to as abstract reasoning (Miller, 1993).

Piaget's theories of intellectual development explain how individuals' understanding of the world changed during development and that children themselves actively constructed the knowledge (Miller, 1993). Piaget (1969) suggested that perception and imagery are figurative processes which could be trained throughout the human life span, and thus that the processes involved in mental imagery applied both to children and to adults (Piaget, 1973; Miller, 1993). Piaget's theories have focused more on the child but less on the external factors surrounding the child. Vygotsky, on the other hand, emphasised the role of external surroundings on the child (Vygotsky, 1978).

3.2 Vygotsky's Zone of Proximal Development

Vygotsky's theory focuses on the influence of external stimulation on development. He defined the lack of external stimulation as cultural deprivation. In terms of cultural and environmental influences on intelligence, Vygotsky (1978) referred to children who did not develop the necessary cognitive skills (in this case, spatial ability), as 'culturally deprived' (Vygotsky, 1978).

A culturally deprived child was defined as one without access to culturally intact situations in which the mediator/cultural agent/caregiver played a vital role (as well as not having access to Westernised learning environments) (Macdonald, 1990). Vygotsky claimed that individuals' attainment of higher mental functions was rooted in the use of physical tools (for example, sticks, lego and blocks) and symbols (for example gesture and language) (Van Niekerk, 1997; Van Eeden, de Beer & Cotzee, 2001).

He emphasised that both physical and symbolic tools were invented in culture and that children come to master such tools during the process of socialisation. In South African society, for example, most females do not get exposed to science and mathematics subjects. In terms of Vygotsky's theory, they would be conceptualised as culturally deprived in these subjects (Nakin, 2003).

Vygotksy also asserted that higher mental functions are integrally tied to social interaction. The importance of social interactions was also illustrated in what he termed the "zone of proximal development" (ZPD). This would be the zone between the level of problem solving an individual can do in isolation and the level of problem solving an individual can do in social situations involving other more knowledgeable individuals (Vygotsky, 1978). This type of zone would be found among students studying together in study groups, in which they had the opportunity to work with more knowledgeable students.

3.3 Feuerstein's Theory of Mediated Learning

Feuerstein's theory of Mediated Learning is based on Vygotsky's theory of intelligence. According to Feuerstein, the mother in the family acts as the primary mediator of verbal learning experiences in the development of a child. Learning is also enhanced in other situations in which a mediator/cultural agent (such as a parent, caregiver, teacher or tutor) plays an important role.

Feuerstein (1980) described a mediator as a person who enriches the interaction between the child and the environment. Mediation would involve working with ingredients that do not (or may not) pertain to the immediate situation, but belong to a world of meanings and intentions representing generations of culturally transmitted attitudes, values, goals and means (Feuerstein, 1980).

Feuerstein maintained that the 'medicine value of human intervention' could potentially enhance, sharpen, focus and frame the child's cognitive capabilities in a number of ways. They could increase his/her capacity to benefit from direct exposure to stimuli in his/her world (Makgoba, 1993). The mediator can therefore be said to intercede between the learning child and the environment in a creative way, by selecting, focusing and feeding back experiences.

A number of studies have focused on Feuerstein's theory of Mediated Learning (MLE), an effective intervention to improve empathy and self-concept as well as cognitive aspects of human functioning (Makgoba, 1993; Burkhalter, 1995). An example of such a study was conducted by Henley (1989), which investigated Feuerstein's theory of mediated learning as the underlying component of structural modifiability.

Henley's sample consisted of 100 disadvantaged pupils who were randomly assigned to an experimental (those receiving Feuerstein's Learning Potential Assessment Device) or control group (ibid, p.33). Henley concluded from this experiment that subjects identified as having had high mediated learning experience were academically achieving at a higher

level than subjects with low mediated learning experience (ibid, p.61). In relation to the study, the researcher will investigate whether female Engineering students perform better when there is mediation such as tutoring or other forms of mediation.

3.4 Stereotype Threat Theory

Stereotype threat refers to the state of being at risk of confirming as self-characteristic, a negative stereotype about one's group. The existence of a negative stereotype about one's group means that anything one does or any of one's features that conform to it make the stereotype more plausible as a self-characterisation in the eyes of others and in some cases in one's own eyes. When the allegation of the stereotype are importantly negative, this predicament may be self-threatening to self and to others (Steel & Aronson, 1995; McGlone & Aronson, 2006).

A stereotype threat is essentially experienced as a self-evaluative threat. In the case of this study, the female engineering students would be conceptualised as a group experiencing the stereotype threat that they cannot outperform men in engineering and that engineering is a field for men only Steel & Aronson, (1995) asserted that after a lifetime of exposure to society's negative images of their ability, students were likely to internalise an inferiority anxiety. This then led them to blame others for their misfortunes and formed a victim's identity (Steele & Aronson, 1995).

In one experiment carried out by Steel & Aronson (1995), African American and European American Stanford University undergraduates completed the verbal portion of the Graduate Records Examination (GRE) after filling out a brief demographic questionnaire. Half of the test takers were asked to fill in their race thereby suggesting that the experimenters were evaluating them with race and hence, the stereotypes about African American and European American students' intellectual abilities – in mind.

This subtle reminder of the stereotype and the possibility of being judged by it aroused enough anxiety among the African American students to make them perform

significantly worse than all other test takers. They solved about half as many problems as those not asked to indicate their race (McGlone & Aronson, 2006).

Following this line of reasoning, it could be argued that women perform badly in Engineering because they have been exposed to the belief that they cannot outperform males in Engineering courses, hence the low performance of females in science and mathematics at school level and at tertiary level (Jawitz, Case & Tshabalala, 2000). However, this theory has been criticised for its internal validity because there could be other reasons for women performing lower than their male counterparts (Whaley, 1998).

3.5 Career Self-Efficacy Theory

Career self-efficacy theory was developed by Hackett and Betz (1981). The concept of self-efficacy refers to one's expectations or beliefs about their ability to successfully perform a given task. Behaviour is determined by these beliefs in that behaviour will be initiated and maintained according to what one believes about one's abilities.

In terms of self-efficacy theory, one's cognitions determine the way one acts (Bandura, 1977). This theory suggests that changeable cognitive factors such as self-perceptions and expectations of success have a significant impact on one's motivation and achievement (Ochse, 2001).

Career self-efficacy theory would suggest that if a woman has high self-efficacy beliefs, she will do well in engineering at university and maintain her excellence in engineering courses. In Hackett and Betz's study conducted in 1981 on university students, they discovered that women had more self-eff'icacy towards careers that were more feminine like nursing, while men had more self-efficacy in male dominated careers like Engineering (Hackett & Betz, 1981).

In this theory, it is also postulated that the way women are socialised is different from men. Women are socialised to be home makers, hence the reason most of them do not

pursue their careers. This socialisation is believed to influence women's cognitive thoughts which in turn influence their self-efficacy and their career decisions (Hackett & Betz, 1981).

In the South African context, educational statistics for 2003 to 2005 show that more girls than boys are enrolled in the South African school system due to the fact that many males drop out of school at an early age. A key concern however, is the values and prejudices that are brought by teachers into the classroom and the potential impact on the mathematics and science performance on girl and boy learners (James et al, 2006).

In terms of career self-efficacy theory, it would be argued that most South African women do not venture into male dominated careers because of the way they have been socialised. When they do attempt male dominated careers such an engineering, they would perform badly due to low self-efficacy, and because they felt that they were deviating from societal rules.

3.6 Aptitudes

Spatial ability is a form of aptitude, and therefore it makes perfect sense to define the term aptitudes for better understanding of this study. Aptitudes are specific abilities utilised in certain areas of achievement (Berk, 2003). An ability such as three dimensional spatial ability would be used in engineering or in architecture.

Aptitudes are formed through the interaction between psychological factors such as motivation and the experiences encountered by an individual on a daily basis (Berk, 2003). Aptitudes are therefore believed to be acquired over time (Cohen & Swerdlik, 2003). Aptitudes may be used to predict one's success in a given career which requires specific abilities (Vosloo, Coetzee & Claassen, 2000). For example higher aptitude scores in spatial ability could be interpreted as indicative of the fact that with further training, that particular individual could remarkably improve their performance in engineering related skills.

It can therefore be deduced that an important aspect of aptitude tests is their predictive function. In this study as in previous studies conducted in Potter and Van der Merwe's research programme, aptitudes such as two dimensional and three dimensional spatial perception have been used to predict the academic performance of engineering students. These two aptitudes have been used as indicators of the spatial abilities of participants in this report.

3.7 Spatial Ability, Perception and Visualisation

Several definitions have been proposed in the literature for these abilities, all having different nomenclatures. These terms are also often used interchangeably, indicating that spatial ability is a non-unitary construct of human intelligence deemed very important in life (Mayer and Sims, 1994; Sternberg, 1990; Linn and Petersen (1985).

Mayer and Sims (1994) define spatial ability as the ability to rotate or fold objects in two or three dimensions and to imagine the changing configurations. Sternberg (1990) states that one's spatial ability pertains with the visualisation of shapes, rotation of objects, and how pieces of a puzzle would fit together. Likewise, Linn and Petersen (1985) indicate that the skills in representing; transforming, generating and recalling symbolic and nonlinguistic information are associated with this ability.

Yet another definition is that "spatial ability concerns the ability to perceive visual or spatial ability information, to transform and modify this information and to recreate visual images even without reference to an original physical stimulus" (Gardener, Kornhaber & Wake, 1996: 207). Gardener et al., (1996) assert that spatial ability is not dependent on visual sensation. This is demonstrated by the fact that many blind people also use this ability when orientating themselves (eg to the spaces within their homes)..

Spatial ability is also believed to be multi faceted comprising of several sub skills. There are different types of spatial ability (Bennett, Seashore, & Wesman, 1974; Carroll, 1993; Stumpf & Eliot, 1999; Nakin, 2003). In a large-scale meta-analysis, Linn and Petersen

(1985) distinguished three different types of spatial ability: spatial perception, mental rotation, and spatial visualisation. Spatial perception requires participants to locate the horizontal or the vertical in a stationary display while ignoring distracting information. Mental rotation involves the ability to imagine how objects would appear when rotated in two- or three-dimensional space (Chan, 2007).

Spatial visualisation refers to complex, analytic multistep processing of spatial information. The usual tasks include the embedded figures test and paper folding. Halpern and LaMay (2000) added two other distinct types of spatial ability namely spatiotemporal ability and the generation and maintenance of a spatial image. The former involves judgments about the responses to dynamic or moving visual displays, and the latter requires participants to generate an image such as the shape of a particular letter of the alphabet, and then use the information in the image to perform a specified cognitive task. The definition that mostly pertains to the purpose of the study is the one given by Chan (2007), which involves the ability to imagine how objects would appear when rotated in two- or three-dimensional space (Chan, 2007).

3.8 Gender Differences in Spatial Ability

Gender differences in spatial ability continue to be widely acknowledged by educators and the media. However, conflicting data exist regarding the actual presence of such a gender difference (Caplan, MacPherson, & Tobin, 1985; Fennema & Sherman, 1977; Maccoby & Jacklin, 1974; Tavris, 1992). In a review of the gender-spatial debate, Caplan et al. (1985) indicated that many of the reported gender differences in spatial ability were very small.

Caplan et al. (1985) further stated that despite this fact, there was a prevalence and resistance to modification of the view that males were superior to females in spatial tasks. One factor attributed to this prevailing view is that of publication bias stating that studies indicating significant differences are more likely to be published than those showing no significant differences (Caplan et al., 1985; Hedges, Shymansky, & Woodworth, 1989).

Halpern (1992) cautioned about publication bias stating that the publication of studies only presenting gender differences were indicative of biased and incorrect conclusions.

Chan (2007) conducted a study aimed at exploring the relationship between spatial experience and spatial ability in a sample of Chinese, gifted students. A total of 337 primary (grades 3 to 6) and secondary (grades 7 to 12) Chinese students participated in the study; 212 were boys, while 125 were girls. Specifically, self-reported spatial experience of students in activities outside the formal curriculum was assessed and related to their spatial ability. The role of spatial experience in contributing to gender differences in spatial ability among students was also explored.

ANOVA Results indicated that the gender main effect was significant, $F(1,333) = 21.66$, $p < .001$ because boys' scores were significantly higher than girls' scores. ANCOVA results on the effect of spatial-orientation experience indicated a nonsignificant effect for boys, $F(1,209)$ but a significant effect for girls, $F(1,122) = 5.64$, $p < .05$ favoring girls with greater spatial-orientation experience. Taken together, the results suggested that even though girls reported less involvement in spatial-orientation activities, compared to boys, spatial-orientation experience could be of greater benefit for girls.

Researchers have also discovered that training and experience could contribute tremendously to reducing the existent gender divide in relation to spatial ability. Feingold (1992) reviewed previous studies on gender differences in spatial ability and concluded that males were more variable than females in several ability categories, including spatial abilities. Feingold (1988) claimed that cognitive gender differences were getting smaller, whereas Voyer, Voyer & Bryden (1995), reviewing studies using subjects born from the year 1902 to 1970, found the evidence for this claim highly questionable.

Men are consistently believed to outperform women in Piaget's famous water-level task. In this task, people see a picture of a container with a certain level of water in it, depicted by a line drawn across the container. People then see the container tilted but empty. The task requires a participant to draw in the water line on the tilted container (Azar, 2008).

Azar (2008) shows that in a study with adults, Vasta (1998) successfully eliminated the gender difference in performing the water-level task by training participants in advance with a session that gave them information about the task and feedback on practice trials. Women who had the training performed slightly better than men who had the training.

When asked to explain the principles behind the task, many more men than women in both the training group and in a control group answered correctly. However, more women in the training group answered correctly than women in the control group.

In addition, earlier non-modernised illiterate societies, women used to perform various spatial tasks, such as weaving, knotting hammocks and constructing contemporary shelters (Halpern, 1992).

Research has also been carried out on two dimensional spatial ability, and generally the results reveal that two dimensional spatial ability has no effect on the academic performance of students. David (2001) conducted a study on sex differences in spatial abilities among adults from the United States and China. Card rotations and cube comparisons were used to tap into participants' two dimensional spatial abilities. Findings revealed no significant sex differences. Roberts and Bell (2001) investigated the effects of age and sex on mental rotation performance, verbal performance and brain electrical activity. Like David (2001), their results yielded no significant sex differences in males and two dimensional spatial abilities and their performance on the tasks they performed (Roberts and Bell, 2001).

3.9 Factors Affecting the Spatial Ability of Females

There have been many competing explanations as to why there is an existence of gender differences regarding spatial ability. Some of the factors include biological factors, environmental factors, age and experience.

3.9.1 Environmental Factors, Gender and Spatial Ability

Gender differences in spatial ability may be caused by several socio-cultural factors such as socialisation. Children's conception of how to behave is shaped by the gender-linked beliefs advocated by their parents (Swim, 1996; Quaiser-Pohl & Lehmann, 2002). Girls are usually not encouraged to pursue an interest in masculine domains which are heavily loaded with spatial reasoning aspects. Females may also underestimate their potentials in spatial fields due to their parental beliefs that affect their self-perception of capability (Fouad & Smith, 1996).

Male children on the other hand, have more opportunities to engage in spatial activities at an early age through gender-biased activities that promote spatial skills development (Baenniger & Newcombe, 1989). The situation is exacerbated by girls' lack of practice that engenders low motivation where engagement in spatial tasks will be discouraged or the likelihood of failure will increase (Stericker & LeVesconte, 1982).

Quaiser-Pohl and Lehmann (2002) further add to this notion of males outperforming females in spatial ability tasks due to lack of experience and motivation and argue that compared to males, females' spatial abilities are extremely vulnerable to and thus modifiable through attitudinal and experiential factors. In addition, Quaiser-Pohl and Lehmann (2002) assert that the fact that females' spatial ability is vulnerable to and is modifiable through attitudinal and experiential factors has considerable consequences for intervention programmes that could help to overcome the gender gap in spatial abilities. A still open question is however, whether experience itself and its spatial nature is that important, or that experience is gender stereotyped.

Another research area relevant to gender differences in spatial abilities focuses on the influence of gender-role orientation on cognitive performance. Gender-schema theories, for example, try to explain gender differences through individual differences in gender-schematic processing of information (Bem, 1981; Martin &Halverson, 1981). According to these theories, individuals build up a gender schema in which knowledge of activities and interests, personality & social attributes, and scripts about gender linked activities are successively included. Once formed, males and females behave consistently with the gender schema that reflects the cultural gender roles.

In addition, another explanation to gender differences in spatial abilities could be attributed to gender role stereotypes. According to Nash's (1979) hypothesis concerning the gender-typing of tasks and Horner's theory of the fear of success (Horner, 1972), individuals perform better on cognitive tasks if their self-concept matches the gender-stereotyping of the task. This assumption has been supported in the field of spatial abilities in that higher masculine and lower feminine self-concept scores were related to better performance in spatial tests (Signorella &Jamison, 1978). Thus, there is strong evidence of a gender-role effect on both academic-course choice and spatial-test performance.

3.9.2 Biological Factors, Gender and Spatial Ability

Geary (1985) on the other hand, has proposed an evolutionary explanation of gender differences in spatial and mathematical abilities, suggesting that the difference reflects a greater elaboration of neurocognitive systems that have evolved for navigating and tracking movement in the three-dimensional universe of males than females. Geary has argued that this evolutionary difference between males and females has developed as a result of the division of labor. Geary's theory has however been criticised at several levels such as biological and experiential levels (Nordik, 1998).

Males and females are generally different as a result of biological differences; hence males and females assume different roles in society. Variables such as rate of maturation, cerebral lateralisation, sex hormones, differential experience and socialisation, and gender-role identification have all been considered relevant from the biological perspective (Voyer, Voyer, Bryden, 1995; Gur, Alsop, Glan, Petty, Swanson, Maldjian, Turetsky, & Detre, 2000; Vogel, Bowers & Vogel, 2003; Hier & Crowley, 1982; Harris, 1978).

3.9.3 Age and Experience as Factors Influencing Spatial Ability

Age related differences in spatial ability were investigated by Piaget and Inhelder (1971) suggesting that an individual's cognitive development determined the potential of what one could achieve. During the final stage of formal operations, which is from 12 years onwards, children not only classified, ordered and reversed mental operations, they could take results of these concrete operations and generate hypotheses about their logical relations (Cockroft, 2002).

A number of studies have also provided findings indicating that spatial skills can be taught (Alington, Leaf, & Monaghan, 1992; Bishop, 1989; Petrusic et al., 1978). It has been asserted that through practice, females improved at a significantly higher rate because men might be operating closer to their maximum potential (Baenniger and Newcombe, 1989). On the other hand, other studies have suggested that there is significant room for improvement of spatial skill for both men and women (Sorby, 1999; Potter, & Van Der Merw, 2003; Potter, Van Der Merwe, Kaufman, & Delacour, J. (2006).

3.10 Women's Access into Engineering and Low Academic Performance in Women studying Engineering

National and institutional documents reveal that strong emphasis is placed on ensuring that student numbers at South African universities reflect the demographics of the

broader population (Department of Education, 2004). However, access remains a complex issue that is impacted upon by a number of factors, including social class, poverty, race and preparedness for higher education.

Women students still tend to be found in certain fields particularly health sciences and humanities. Nationally, statistics show that the Classification of Education Study Material (CESM) category (i.e. the field of study) that has the lowest proportion of women students is Engineering. In 2001, only 17.1% of the students in this category across South Africa were women (Department of Education, 2004).

There are many reasons as to why South African women are few in the field of Engineering in higher education. Some of the reasons include the way science is taught in class at school level, not having aspirations for Engineering, external factors like influences from family and friends (Jawitz & Case, 1998) Other reasons include lack of exposure to and less information about Engineering and the difficulty of entry into the course (Jawitz & Case, 1998).

Some women also do not study Engineering because they fall pregnant at secondary school level and may end up not going back to study, while others are faced with societal pressures of getting married and starting a family (Jawitz & Case, 1998).This is because they believe that if they are too educated, they will not find men who will marry them as these men will be intimidated by an educated woman who has studied a male dominated course of Engineering.

Parental attitudes also play a huge role in most women not participating in Engineering (Martineau, 1997; Jawitz & Case, 1998). Some parents encourage their sons to study Engineering and discourage their daughters to study Engineering because it is a male dominated course and they might be exposed to danger. Some teachers also play a role in that they encourage boys and expect boys to outperform girls in science mathematics in classrooms (Martineau, 1997).

Kaufman (2000) discovered that some women reported difficulty in mentally visualising the two-dimensional and three dimensional objects due to lack of spatial ability, hence the low academic performance in the first year Engineering Graphics at the University of the Witwatersrand. Kaufman also reported that the female students who expressed difficulty in visualising the two as well as three dimensional objects experienced difficulty in terms of success in the first year Engineering Graphics course. These students attributed their difficulty to a lack of previous experience in drawing. This was because they had not taken technical drawing at school level.

3.11 Summary

Piaget (1969) suggested that perception and imagery are figurative processes which could be trained throughout the human life span, and thus that the processes involved in mental imagery applied both to children and to adults (Piaget, 1973; Miller, 1993).

The two main research questions in this report are how female engineering students cope with their studies and whether three dimensional spatial ability is an influence in their coping. As Piaget has already discovered, both physical and symbolic tools were invented in culture and that children come to master such tools during the process of socialisation. Given most females in South African societies do not get exposed to science and mathematics subjects, issues like these could hamper their performance, hence the report will tap into things that influence females' academic performance (Nakin, 2003). Some of these issues will include females' cultural deprivation from engineering related subjects as suggested by Vygotsky (Nakin, 2003), or mediation from tutors and lecturers as suggested by Feuerstein Feuerstein (1980). As already mentioned earlier, one of the sub questions compares males' and females' academic problems and coping mechanisms. In relation to the study, the researcher will investigate whether female Engineering students perform better when there is mediation such as tutoring or other forms of mediation.

Other issues that are viewed as influential in females' performance include stereotyping, age, biological, environmental and gender issues (Steel & Aronson, 1995; Swim, 1996;

Quaiser-Pohl & Lehmann, 2002; Geary, 1985). All these issues in the literature are to be looked into in more detail in the project, with particular focus on methods adopted by students in coping with their engineering studies, as well as whether three dimensional spatial ability is indeed an influence in academic performance or whether there are other influences.

Chapter 4 Research Methodology

4.1 Research Design

This study has used a multimethod research design. Qualitative data were gathered through interviews. This part of the design was cross sectional because data collection took place for all students at a single point in time (Rosnow & Rosenthal, 1996).

Trends from the qualitative analysis were then interpreted in relation to indicators relating to the development of spatial ability in the course context. The indicators for level of spatial ability were quantitative, based on previous research conducted on the first year Englineering graphics course which had indicated a consistent relationship between psychometric tests measuring spatial ability and academic performance (Potter, Van der Merwe, Kaufman & Delacour, 2006). This part of the study was based on a non-experimental, cross sectional design (no random assignment of participants, no control group and no variable manipulation).

4.2 Samples of Students

4.2.1 Sample Used in the Qualitative Side of the Study

The qualitative data for this study were drawn from a non-probability convenience sample. Non-probability sampling is a type of sampling where individuals or participants are easily available and are willing to participate in the study (Rosnow & Rosenthal, 1996).

The sample for the qualitative side of the analysis consisted of 40 first year Engineering students. However, there was some attrition. Ultimately, 36 interviews were conducted as the other four students cancelled their interviews at the last minute. 9 of the interviewed students were female engineering students taking the mainstream Engineering Graphics course and 9 male students taking the same course. Another 9 of these students were

female Engineering students taking a special Engineering Graphics course for students with difficulties with the course content, and 9 male students taking the same course.

The special course was provided to students who performed badly in the first year Engineering Graphics course over the first quarter of the year, and were provided with special tuition by their lecturer. The aim of the additional tuition provided to special class students was to improve their academic performance in the course. The mainstream course was provided to the remaining students (ie to students who had not performed badly over the first quarter).

The male and female students selected for interview from both the mainstream and special classes were matched on three dimensional spatial abilities using data from a test of three dimensional spatial perception, which was administered to all first year engineering students as part of ongoing course evaluation.

4.2.2 Sample Used in the Quantitative Side of the Study

All students in both the mainstream and special courses were tested (a total of 260 students, 184 of whom were taking the mainstream and 76 the special first year Engineering Graphics course) Academic performance data on the June examination in first year Engineering Graphics was then collected for each of the students.

4.3 Instruments

4.3.1 Qualitative Instruments

Qualitative data were gathered through the use of a self-constructed semi-structured interview schedule. This was in questionnaire format and consisted of four sections. Section One required the participants to provide their demographic education. The second section required the participants to give information regarding their school background as

well as their family background with focus on their parents' occupations. Section Three was on the stereotypes in Engineering graphics while in Section Four, participants were asked to provide comments on their experiences of the first year Engineering Graphics course.

The instrument was constructed using a number of open-ended questions. The questions in the questionnaire and how they relate back to the literature are provided below.

Table 4.1 Questions in the Interview Schedule, and their Relationship with the Literature Review

Gender	A comparison was made regarding the performance and coping mechanisms utilised by male and female students, as it has been found that female students tend to do badly in mathematics and science courses (Steele & Aronson, 1995), as well as in courses in Engineering and technology (Steele & Aronson, 1995). Potter, Van der Merwe, Kaufman and Delacour (2006) reported that female students experienced difficulties with the Engineering graphics course, and recommended that gender issues be explored in more depth in future studies.
Group	A comparison was made of the performance between mainstream and special programme participants. The special programme group is comprised of students with poorly developed spatial abilities. It has been established at both the University of the Witwatersrand and other Southern African universities that Engineering students who do not have well developed three dimensional spatial abilities are at risk of not passing their first year graphics courses (Behr, 1982; Mauvis, 1979; Millroy & Rochford, 1985; Taylor, 1978; 1981).
Where did you attend school; private or public	Taylor (1978) found out that biographical

school?	information, such as school type and parents education for example, correlated considerably with academic success.
Do you think the school one attended could have had an effect on their performance in Engineering graphics?	Taylor (1978) found out that biographical information, such as school type and parents education for example, correlated considerably with academic success. Kaufman (2000) found other variables influential in terms of the students' academic performance in the graphics course. These were identified as previous experience, cross-cultural differences and gender issues.
At your school, did you have career guidance regarding technical courses like drawing, design and woodwork?	A key concern has been on the values and prejudices that are brought by teachers into the classroom and the potential impact on the mathematics and science performance on girl and boy learners (James et al, 2006).
Did you have aptitude tests? If not, do you think if you had you would have been able to do better in the F and the three dimensional spatial perceptions?	Aptitudes are specific abilities utilised in certain areas of achievement (Berk, 2003) such as three dimensional spatial ability being used in Engineering or in architecture. Aptitudes are formed through the interaction between psychological factors such as motivation and the experiences encountered by an individual on a daily basis (Berk, 2003; Cohen & Swerdlik, 2003). Aptitudes are therefore believed to be acquired over time.
What are your mother's and your father's occupations and have your parents influenced your career choice?	Taylor (1978) found out that biographical information, such as school type and parents education for example, correlated considerably with academic success. Swim (1996) also asserted that children's conception of how to behave was shaped by the gender-linked beliefs advocated by their parents (Swim, 1996).
What is your opinion of the stereotypes held about women who study Engineering?	It has been argued that women could be performing badly in Engineering because they have been exposed to the belief that they cannot outperform males in Engineering courses, hence the low

	performance of females in science and mathematics at school level and at tertiary level (Jawitz, Case & Tshabalala, 2000).
What is your experience of the Engineering graphics course since the beginning of the first quarter?	Kaufman (2000) discovered that some women reported difficulty in mentally visualising the two-dimensional and three dimensional objects due to lack of spatial ability, hence the low academic performance in Engineering Graphics. Kaufman (2000) also discerned that the female students who expressed difficulty in visualising the two as well as three dimensional objects or experienced difficulty in terms of success in the Engineering graphics course also attributed their difficulty to a lack of previous experience in drawing. This was because they had not taken Technical Drawing at school level.
How did you find the first test in Engineering graphics?	Potter's & Van der Merwe's (Potter & Van der Merwe 1982; 1983; 1992; 1995; Van der Merwe & Potter, 2000) findings suggest that students vary in spatial ability and that students with low scores on tests of three dimensional spatial ability are at risk as regards passing Engineering graphics courses.
How do you find assignments and the coursework as a whole?	Kaufman (2000) did a study on students' perceptions of the role of mental imagery in academic performance in first year Engineering graphics. Her findings indicated that a number of factors were influential in terms of academic performance in Engineering graphics. The students in the sample reported that mental imagery was an important aspect when drawing three-dimensional sketches and many felt that their inability to form these images affected their academic performance in the Engineering graphics course.
How did you find the two dimensionaland the three dimensional spatial perception tests?	Kaufman (2000) did a study on students' perceptions of the role of mental imagery in

	academic performance in first year Engineering graphics. Her findings indicated that a number of factors were influential in terms of academic performance in Engineering graphics. The students in the sample reported that mental imagery was an important aspect when drawing three-dimensional sketches and many felt that their inability to form these images affected their academic performance in the Engineering graphics course.
What do you think contributed to the score you attained in two dimensional and the three dimensional tests of spatial ability?	Kaufman (2000) did a study on students' perceptions of the role of mental imagery in academic performance in first year Engineering graphics. Her findings indicated that a number of factors were influential in terms of academic performance in Engineering graphics. The students in the sample reported that mental imagery was an important aspect when drawing three-dimensional sketches and many felt that their inability to form these images affected their academic performance in the Engineering graphics course.
Do you think three dimensional spatial ability influences one's performance in Engineering graphics?	Studies previously conducted at the University of the Witwatersrand have indicated that that there is a consistent relationship between spatial ability (and in particular three dimensional spatial perception) and the academic performance of first year Engineering graphics students (Taylor, 1978; 1981; Potter, Van der Merwe & Kaufman, 2003; Potter, Van der Merwe, Kaufman & Delacour, 2006). Three dimensional spatial perception was chosen as a particular focus in this study because it has been established that this factor is a firm predictor of academic performance in Engineering Graphics (Taylor, 1978; 1981; Potter, Van der Merwe & Kaufman, 2003; Potter, Van der Merwe & Kaufman).

How do you go about studying for Engineering graphics?	Kaufman (2003) focused on the experiences of female Engineering students and their study strategies such as practical tutorial examples, keeping up to date with work and study groups as well as understanding of concepts.
Do you think similar strategies are effective in studying all first year Engineering subjects or are different strategies necessary in studying Engineering graphics?	Kaufman (2003) found out from her interviews with participants that it was important to understand concepts in order to do well in other subjects.
What in your opinion, should be done to improve the performance of women who study Engineering and also to help them bridge the gap from school to university?	Potter, Van der Merwe and Kemp (1984; 1987) reported that three dimensional spatial ability could be improved with appropriate instruction. Van der Merwe and Potter (2000) have published materials which aim to improve visualisation abilities. Kaufman (2001; 2003) reported that students who used these materials reported improved performance in Engineering graphics.

4.3.2 Piloting the Interview Schedule

The interview schedule was first piloted on two first year male and two female Engineering students who did not take part in the interviews. One question was found to be redundant and was therefore removed from the questionnaire. This question required participants to indicate whether they had studied higher level maths and science at school. They indicated that it was a requirement that all Engineering students should have done these subjects at higher grade at school.

4.3.3 The Quantitative Instruments

The spatial abilities of the students were established through two psychometric tests, the F Test (measuring two dimensional spatial perception) and the H Test (measuring three dimensional spatial perception). Both these instruments have been widely used in Southern African universities.

They were first adapted for use by Deregowski (1976) and Mauvis (1978) working in Zimbabwe. Both instruments were then included by John Taylor of the NIPR in his test battery used with engineering students in two studies conducted at the University of the Witwatersrand (Taylor, 1980; 1981).

Taylor reported that both the F test and the H test had high reliability of 0.78 (Taylor, 1980; 1981). Delacour (2004) then reviewed data on the H test gathered over a twenty year period, and found the test to be reliable, with reliability coefficients ranging between 0.80 and 0.90 for the years 1982, 1983, 1992, 2000 and 2001. The H test has also been found to have a consistently firm relationship with academic performance in Engineering Graphics over a twenty year period (Potter, Van der Merwe, Kaufman & Delacour, 2006).

4.4 Procedure

The F test and the H test were administered to all the first year engineering students to establish the levels of each of the students in two dimensional and three dimensional spatial perception. Data on the two tests were thus available for a sample of 220 students in the mainstream first year Engineering Graphics course, and also for a sample of 80 first year Engineering students who were taking a special course in Engineering graphics. These data were used to select 36 students (9 male mainstream students; 9 female mainstream students; 9 male special course students; 9 female special course students) from these two courses for interview. The male and female students were matched on level of three dimensional spatial perception.

The aim was to contrast the study and coping strategies used by female as opposed to male students in both courses. This was done by conducting interviews with both male and female students to get an in-depth view of their experiences in the first year Engineering graphics course, as well as the strategies they have adopted to cope with

difficulties encountered in the course. The interviews were then transcribed and analysed with thematic content analysis.

The data from the F and H tests were examined in relation to the June examination marks obtained by the students, to establish the relationship between two dimensional and three dimensional spatial perception and academic performance in the course. The quantitative analyses performed on the data included correlation, backward stepwise regression, two-independent tests, Fisher's Z transformation and two-way ANCOVA.

4.5 Data Collection and Organisation

The students were given a questionnaire by their lecturer requiring their demographic information. The students were also interviewed individually at a time agreed upon by the researcher and the students. The interviews were tape recorded and then transcribed. The purpose of the interviews was to get an in-depth understanding of the students' experiences in the Engineering Graphics course, particularly female Engineering students.

The students' scores on the F test and H test, together with their scores on the June examination and the interviews were then utilised to investigate the students' experiences as well as their adaptation as a whole to first year Engineering.

4.6 Data Analysis

4.6.1 A Multimethod Approach

The researcher used a multimethod approach in that she used both quantitative and qualitative methods of data collection. This was achieved through the administration of the F and H tests (which yielded scores representing the students' levels of two

dimensional and three dimensional spatial perception respectively) and through the use of interviews.

The quantitative data provided an indication of each student's level of spatial ability. The interviews on the other hand, provided information on the coping methods adopted by female Engineering students and their adaptation mechanisms to university. These methods were also compared to those used by their male counterparts. Lastly, the interviews also provided some information on what could be done to improve female students performance regarding Engineering graphics; a compulsory course in the Engineering course.

4.6.2 Quantitative Data Analysis

The quantitative analysis in this report was structured so as to answer the research questions as presented in Chapter One. The quantitative data yielded by both the F and H tests were first analysed descriptively, after which a correlation analysis was performed to determine whether a relationship existed between two dimensional and thre dimensional spatial perception and academic performance.

The next step in the analysis was to establish whether this relationship, if it existed, was different for males and females, hence Fisher's Z statistic was applied to establish this. The researcher had also set out to find out if academic performance differed between male and female engineering students. This was accomplished with the use of a two independent sample t-test.

The last research question was on whether different relationships existed between gender, group, two dimensional spatial perception, three dimensional spatial perception and academic performance in students who were receiving special tuition for their difficulties, as compared to the relationships between these variables and academic performance of other students in first year Engineering graphics. This was determined with the use of a two-way ANCOVA.

4.6.3 Qualitative Data Analysis

The researcher carried out interviews using a self-made semi-structured questionnaire. The interviews were tape recorded and then transcribed, after which thematic content was used to analyse the transcribed interviews. First she set out to find out what strategies were used by female engineering students in making a transition from school to university. She then looked into whether strategies employed by these females were effective in studying all first year Engineering subjects or whether different strategies were necessary in studying Engineering graphics.

In addition, the interviews tapped into whether male Engineering students used similar strategies to female students in coping with the demands of their first year courses. The researcher also looked into the coping strategies that were necessary for female Engineering students who had poorly developed three dimensional spatial ability as opposed to well developed three dimensional spatial ability, and whether those strategies were similar to those adopted by male Engineering students with poorly developed three dimensional spatial ability as opposed to well developed three dimensional spatial ability.

Finally, the researcher investigated if there were other influences on the students' academic performance, and if they were similar for males and females, as well as for students receiving special tuition for their difficulties, versus those in the mainstream programme. This was done by clustering themes in the data yielded by each of these groups.

4.7 Summary

This study is multimethod in nature, conducted with a sample of first year Engineering students. The whole first year Engineering class were tested on their spatial abilities using the F test, (which measures two dimensional spatial ability) and the H test (which

measures three dimensional three dimensional spatial perception) in the second quarter of the academic year.

40 participants (20 males and 20 females) were randomly selected to take part in the interviews. 4 of the students did not show up for the interviews, and after being recontacted opted not to take part in the study. Only 36 students (18 males and 18 females) thus participated in the interviews.

The purpose of the interviews was to find out what methods were utilised by first year female engineering students in making the transition to university and whether these methods were similar to those adopted by male students in adapting to university life. Correlations were then calculated between these students' F test and H test scores and their academic performance. Gender and participation in a special course involving a support programme organised by the School of Mechanical Engineering was also included in the analysis, with two dimensional spatial ability also being considered as a co-variate. The researcher utilised a self-constructed semi- structured questionnaire to gather qualitative data as well as previously standardised two dimensional and three dimensional spatial perception tests with a long history of reliability (Taylor, 1980; 1981; Delacour, 2004), in terms of the following design:

Table 4.2 Research Design Table

Research Questions	Data Sources	Data Collection	Data Analysis	Sampling
How do female Engineering students cope with their studies?	Interviews with first year Engineering students	Researcher	Thematic Analysis	9 mainstream first year female Engineering students 9 Special Programme first year female Engineering students 9 mainstream first year Engineering boys 9 Special Programme first year Engineering boys

What strategies are used by female Engineering students in making the transition from school to university?	Interviews with first year Engineering students	Researcher	Thematic Analysis	9 mainstream first year female Engineering students 9 Special Programme first year female Engineering students 9 mainstream first year Engineering boys 9 Special Programme first year Engineering boys
Are similar strategies effective in studying all first year Engineering subjects, or are different strategies necessary in studying Engineering Graphics?	Interviews with first year Engineering students	Researcher	Thematic Analysis	9 mainstream first year female Engineering students 9 Special Programme first year female Engineering students 9 mainstream first year Engineering boys 9 Special Programme first year Engineering boys
Do male Engineering students use similar strategies to female students in coping with the demands of their first year courses?	Interviews with first year Engineering students	Researcher	Thematic Analysis	9 mainstream first year female Engineering students 9 Special Programme first year female Engineering students 9 mainstream first year Engineering boys 9 Special Programme first year Engineering boys
Is three dimensional spatial perception an influence on how female Engineering students cope with their studies?	Interviews with first year students three dimensional spatial perception scores two dimensional spatial perception scores June Exam Marks	Researcher Engineering Lecturer	Thematic Analysis	9 mainstream first year female Engineering students 9 Special Programme first year female Engineering students 9 mainstream first year Engineering boys 9 Special Programme first year Engineering boys
Research Questions	**Data Sources**	**Data Collection**	**Data Analysis**	**Sampling**
What coping strategies are	Interviews with first year	Researcher	Thematic Analysis	9 mainstream first

necessary for female Engineering students who have poorly developed three dimensional spatial ability as opposed to well developed three dimensional spatial ability?	Engineering students			year female Engineering students 9 Special Programme first year female Engineering students 9 mainstream first year Engineering boys 9 Special Programme first year Engineering boys
Are these strategies similar to those adopted by male Engineering students with poorly developed three dimensional spatial ability as opposed to well developed three dimensional spatial ability?	Interviews with first year Engineering students	Researcher	Thematic Analysis	9 mainstream first year female Engineering students 9 Special Programme first year female Engineering students 9 mainstream first year Engineering boys 9 Special Programme first year Engineering boys
Are there other influences on the students' academic performance, and are they similar for males and females, as well as for students receiving special tuition for their difficulties, versus those in the mainstream programme?	Interviews with first year Engineering students	Researcher	Thematic Analysis	9 mainstream first year female Engineering students 9 Special Programme first year female Engineering students 9 mainstream first year Engineering boys 9 Special Programme first year Engineering boys

Chapter 5 Quantitative Results

5.1 Introduction

This chapter reports the results of the analyses conducted on the data yielded the F and the H tests administered in 2007 to all the engineering students at the beginning of the second quarter of the academic year. The aim of the analyses was to determine whether the academic performance of both male and female students could be ascribed to the influence of both two dimensional and three dimensional perception.

The data from both tests were thus analysed in a number of different ways, to establish whether both two and three dimensional spatial perception had a similar level of relationship with academic performance of the students. Analysis was also undertaken to establish whether this relationship was similar for male and female students, as well as for students taking the mainstream as opposed to the special first year Engineering Graphics course.

5 .2 Statistical Analyses to address Research Question One

- Is three dimensional spatial perception an influence on how first year female Engineering students cope with their studies?

A series of statistical analyses were conducted to answer the first research question. Each of the analyses addressed a separate question, as follows:

- Is there a relationship between both two dimensional spatial ability and three dimensional spatial perception and the academic performance of all first year students in Engineering Graphics?
- Does the relationship between both two dimensional spatial ability and three dimensional spatial perception and academic performance differ in the case of male and female engineering students?
- Is the academic performance of male and female engineering students different?
- Are there different relationships between gender, group, two dimensional spatial perception, three dimensional spatial perception and academic performance in students who are receiving special tuition for their difficulties, as compared to the

relationships between these variables and academic performance of other students in first year Engineering Graphics?

Table 5.0 Results Summary

1. Descriptive Statistics	Table 5.1 descriptive statistics for gender and group for special programme, mainstream and all engineering classes	Table 5.1 describes the nominal variables namely the special programme , mainstream .and all engineering classes
	Table 5.2 descriptive statistics for f test scores, h test scores and june exam mark for special programme, mainstream and all engineering classes	Table 5.2 describes interval variables namely the F test scores, H test scores and the june exam marks for the, special programme, mainstream all engineering classes
2. Correlation Analysis	Table 5.3 correlation between F test (two dimensional) scores, H test (three dimensional) scores and June exam marks for the special programme, mainstream and all engineering classes	Q a. Is there a relationship between both two dimensional spatial ability and three dimensional spatial perception and the academic performance of all first year students in engineering graphics?
3. Backward Stepwise Regression	Table 5.4 Backward Stepwise Regression for Special Programme, Mainstream, and all engineering participants	Q a. Is there a relationship between both two dimensional spatial ability and three dimensional spatial perception and the academic performance of all first year students in engineering graphics?
4. Fisher's Z Transformation	Table 5.5 Pearson Correlation Statistics (Fisher's Z Transformation) for the males' and females' differences in academic performance and spatial ability	Q b. Does the relationship between bothtwo dimensional and three dimensional spatial abilities and academic performance differ between males and females?
5.Two Independent T Tests	Table 5.6 T tests for gender and group for all engineering participants, special programme class and mainstream class	Q c. Is the academic performance of male and female engineering students different?
6. ANCOVA	Table 5.7 ANCOVA for Gender and Group	Q d. Are there different relationships between gender, group, two dimensional spatial perception, three dimensional spatial perception and academic performance in students who are receiving special tuition for their difficulties, as compared to the relationships between these variables and academic performance of other students in first year engineering graphics?

5.3 Descriptive Statistics

In the sample of first year engineering students tested, there were 190 males and 70 females. Of these, there were 184 students being taught in mainstream lectures and 76 students being taught in a special programme as shown in table 5.1. The special programme sample has 57 males and 19 females as represented in the table. Table 5.1 further shows that for the mainstream class, there are 133 males and 51 females.

Table 5.1 Descriptive statistics for gender and group for the Special Programme, Mainstream and Overall Engineering participants

	Male	Female
Special Programme Class	57	19
Mainstream Class	133	51
Overall Engineering Class	190	70

In table 5.2, the descriptive statistics for the F test scores (two dimensional spatial perception), H test scores (three dimensional spatial perception) and June examination marks (academic performance) are presented for all three samples namely the special programme, mainstream and overall engineering class

For the special programme, the H test had a mean of 13.22 with a standard deviation of 5.29. The table also indicates that the F test had a mean of 21.8 and a standard deviation of 8.13. For this group, the June exam marks had a mean of 56.35 and a standard deviation of 9.92.

Table 5.2 also shows that for the mainstream group, the H test had a mean of 23.57 and a standard deviation of 7.48, while the F test had a mean of 25.84 and a standard deviation

of 9.28. The academic performance for this group had a mean of 60.26 and a standard deviation of 11.48. Table 5.2 further shows that for the overall engineering class, the H test had a mean of 20.55 and a standard deviation of 8.36 while the F test had a mean of 24.66 and a standard deviation of 9.13. The June examination marks had a mean of 59.11 and a standard deviation of 11.17.

These descriptive statistics indicated that there was sufficient spread in the data from all variables and for all groups to proceed further with the analysis.

Table 5.2 Descriptive statistics for F test scores, H test scores and June Exam mark for special programme, mainstream and all the engineering participants

	Special Programme Class			**Mainstream Class**			**Overall engineering class**		
Variable	three dimensional spatial perception	two dimensional spatial perception	Academic performance	three dimensional spatial perception	two dimensional spatial perception	Academic performance	three dimensional spatial perception	two dimensional spatial perception	Academic performance
N	76	76	76	184	184	182	260	260	258
Mean	13.22	21.8	56.35	23.57	25.84	60.26	20.55	24.66	59.11
Std. Dev.	5.29	8.13	9.92	7.48	9.28	11.48	8.36	9.13	11.17
Min	2	3	29	5	5	26	2	3	26
Max	34	41	78	38	43	88	38	43	88

5.4 Trends in Academic Performance for Special Programme, Mainstream and all Engineering Participants

Research Question One (a)

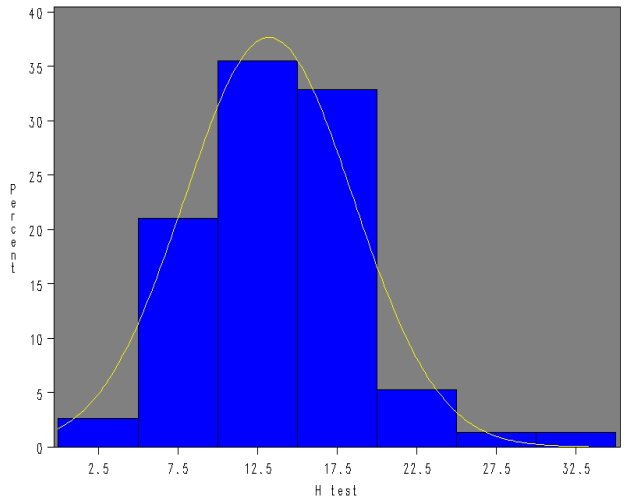
- **Research Question a (i).** Is there a relationship between both two dimensional spatial perception and three dimensional spatial perception, and the academic performance of all first year students in Engineering Graphics? (correlation)

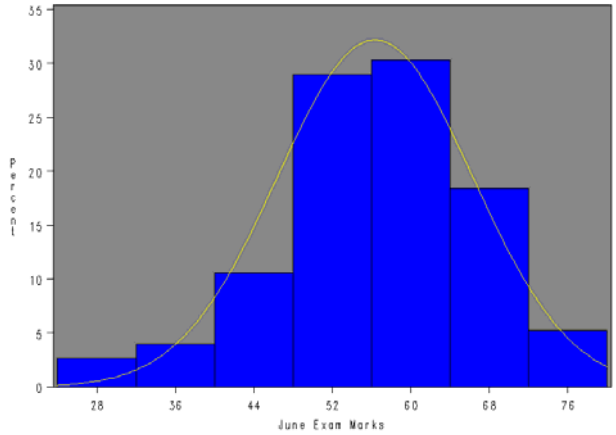
The question was answered by means of Pearson's correlation analysis as well as a backward stepwise regression to establish if two dimensional and three dimensional spatial perception, gender and group (mainstream versus special course) were related to academic performance and whether they were predictive of academic performance. Correlations were calculated between the participants' two dimensional and three dimensional spatial perception and academic performance using the June examination marks for the special programme participants, mainstream as well as the overall engineering participants. Correlations were also determined between the students' two dimensional spatial perception and their academic performance.

5.5 Assumptions of a correlation

The assumptions for correlation are that the distributions of both variables related by the coefficient of correlation should be normally distributed and that the scatter-plots should be linear and homoscedastic (Cohen, Cohen, West & Aiken, 2003). Fig 5.1 illustrates that the normality assumption was met as the variables seem to follow a more or less normal distribution.

Fig 5.1 Normality Assumption





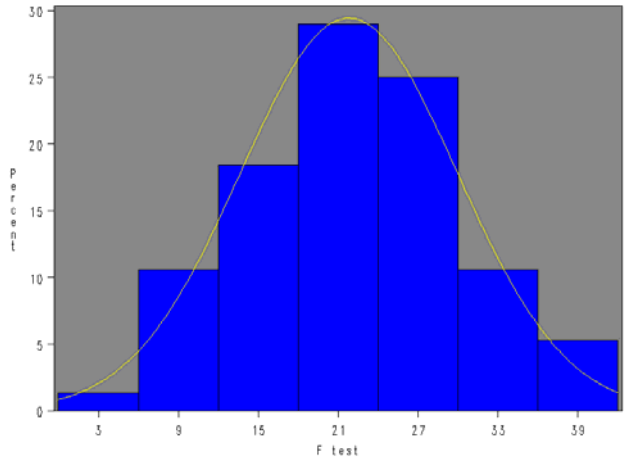


Table 5.3 presents the correlations between three dimensional spatial perception and academic performance for special programme, mainstream and the all engineering participants. The special programme sample has a moderate correlation of (r=0.31; p=0.0005) between three dimensional spatial perception and academic performance. The table further shows that for the special programme sample, a relationship exists between two dimensional spatial perception and academic performance (r=0.42; p=0.0001).

For the mainstream sample, a correlation exists between three dimensional spatial perception and academic performance (r=0.48; p<0.0001) as well as between two dimensional spatial perception and academic performance (r=0.33; p<0.0001). From table 5.3 it is also evident that for the overall engineering class there is a moderate correlation between three dimensional spatial perception and academic performance as r=0.45 and p-value is <0.0001. The correlation coefficient for two dimensional spatial perception and academic performance is shown to be 0.37 at a p-value of <0.0001.

Table 5.3 Correlation between two dimensional spatial perception, three dimensional spatial perception and academic performance for Special Programme, Mainstream and all Engineering participants

Pearson Correlation Coefficients, Prob> |r| under H0: Rho=0			
	Variable	**R**	**p-Value**
Special Programme Class	three dimensional spatial perception two dimensional spatial perception	0.31 0.42	0.005 0.0001
Mainstream	three dimensional spatial perception two dimensional	0.48 0.33	<0.0001 <0.0001

	spatial perception		
Overall Engineering Participants	three dimensional spatial perception two dimensional spatial perception	0.45 0.37	<0.0001 <0.0001

Special Programme N= 260 Mainstream N= 186 All Engineering Class N= 260

- **Research Question a (ii)**. Is there a relationship between two dimensional spatial perception, three dimensional spatial perception and the academic performance of all first year students in Engineering Graphics? (backward stepwise regression)

A *backward stepwise regression* was determined to find out whether two dimensional and three dimensional spatial perception as well as group and gender were predictive factors in the students' academic performance in first year Engineering Graphics. Academic performance served as the dependent variable for which the variance was being determined.

5.6 Assumptions of Backward Stepwise Regression

Assumptions for a regression analysis include *equality of variance*, *normal distribution* and a *random selection of the sample*. The assumption of random selection of the sample was not met because the administration of the F test and the H test was not done randomly. Both tests were administered to the whole class.

Normality of variance was tested using the studentised residual table for the dependent variable namely the June examination marks (academic performance). There was equality of variance because the scatter graph was more or less equal on both sides of the graph as indicated in figure 5.2 below. Normality of distribution of the dependent variable (June

exam marks) is indicated in the almost bell shaped graph of the distribution of variables in fig 5.2

5.7 Potential Problematic Characteristics of a Backward Stepwise Regression: Collinearity

Collinearity refers to a high correlation amongst the independent variables, making it hard for one to interpret the meaning of regression coefficients. Correlations were run for the independent variables and they were found to be highly correlated; two dimensional spatial perception and three dimensional spatial perception had a correlation of 0.67 at a p value of <0.0001, which is highly significant, as indicated in table 5.4.

Collinearity was thus a possible issue, and was checked using condition index tests and eigen values. In cases where no collinearity exists, all eigenvalues would be 1. Eigenvalues smaller or larger than 1 would indicate departures from the ideal situation. Too small or too large eigenvalues would indicate multicollinearity problems.

In the case of this analysis, table 5.3 indicates that the eigen values were not too small nor too large. It was therefore concluded that collinearity was not a great issue (Cohen, Cohen, West & Aiken, 2003; Howell, 2008), and unlikely to affect the results of a backward stepwise regression.

From table 5.5, the condition indices were 1, then 1.25 and 1.89. Ideally, a good condition index should be less than 10, indicating that the IVs are not correlated. A condition index of 20 is also acceptable, but anything from 30 and above is not acceptable (Cohen, Cohen, West & Aiken, 2003). Values above 30 would indicate that the IVs were highly correlated, which would be problematic (Rosenthal & Rosnow, 1991).

Based on the values of the condition indices, it was therefore deduced that the assumption of collinearity was met in this project. The results of backward stepwise regression for

special programme, mainstream and overall engineering participants are illustrated in table 5.6

Table 5.4 Pearson Correlation Coefficients

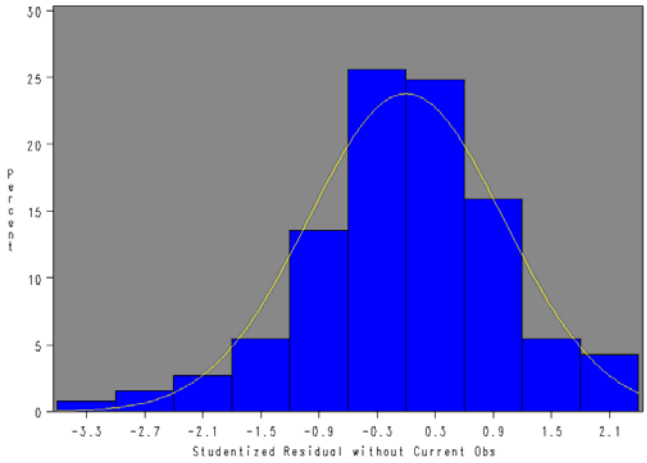
	Gender	H test	F test	June exam marks	Group
Gender	1 260				
H test	0.01403 0.8219 260	1 260			
F test	0.09005 0.1476 260	0.67973 <0.0001 260	1 260		
June exam marks	-0.17418 0.005 258	0.45608 <0.0001 258	0.3758 <0.0001 258	1 258	
Group	-0.02786 0.6547 260	-0.56417 <0.0001 260	-0.20152 0.0011 260	-0.15974 0.0102 258	1 260

Table 5.5 Collinearity Diagnostics

Number	**Eigenvalue**	**Condition Index**	Gender	H test	Group
1	1.56	1.00	0.002	0.21	0.07
2	0.99	1.25	0.99	0.002	0.01
3	0.43	1.89	0.0008	0.91	0.45

Figure 5.2 Normality of Distribution and Equality of Variance

Normality of distribution



Equality of Variance

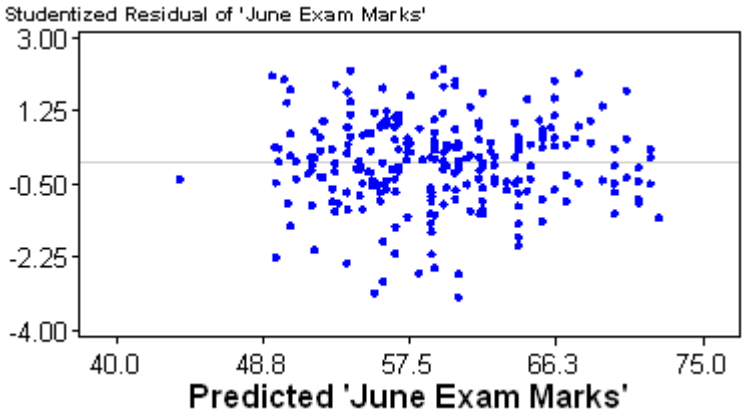


Table 5.6 Backward Stepwise Regression for Special Programme, Mainstream and all Engineering participants

	Variable	t-value	p-Value	F-value	R-Square
Special Programme Class	Intercept F test	15.10 4.06	<0.0001 0.0001	16.47	0.18
Mainstream	Intercept Gender H test	15.37 -3.10 7.56	<0.0001 0.0023 <0.0001	33.65	0.27
Overall Engineering Class	Intercept Gender H test Group	7.99 -3.29 8.17 2.10	<0.0001 0.0012 <0.0001 0.036	28.8	0.25

Table 5.6 presents backward stepwise regression results for the special programme, mainstream and the overall engineering participants. The results in this table reveal that for the special programme participants, two dimensional spatial perception is the only variable significant at $\alpha = 0.05$. two dimensional spatial perception has a t-value of 4.06 at a p value of 0.0001.

Table 5.6 also reveals that the R square is 0.18, illustrating that the proportion of variance accounted for by the predictor variable on the dependent variable is 18 %. With regards to the mainstream group, it is clear from table 5.6 that gender and three dimensional spatial perception remained in the model after a backward stepwise elimination. The

proportion of variance accounted for by the predictive variables is 27% for the mainstream sample as the R-Square is 0.27.

For the overall engineering participants, group, gender and three dimensional spatial perception were the variables remaining in the regression model after two dimensional spatial perception was taken out of the model as it was not significant at $\alpha = 0.05$. In other words, the variable did not add much to the model. The table also indicates that gender has a t-value of -3.29 and a p-value of 0.0012, three dimensional spatial perception has a t-value of 8.17 with a p-value of <0.0001. Group has a t-value of 2.10 and a p-value of 0.036. From table5.4, it is revealed that the R square is 0.25, indicating that the proportion of variance accounted for by the predictor variables is 25%.

It is important to note that for both the overall sample and mainstream participants, gender and especially three dimensional spatial perception were significant predictors in the proportion of variance in the dependent variable (academic performance), whereas two dimensional spatial perception was an important predictor for special programme participants.

- **Research Question b.** Does the relationship between both two dimensional spatial perception and three dimensional spatial perception and academic performance differ in the case of male and female engineering students? (Fisher's Z transformation).

To answer this question, Fisher's Z transformation was performed on the correlation computed for males and females. Fisher's Z transformation has different uses namely:

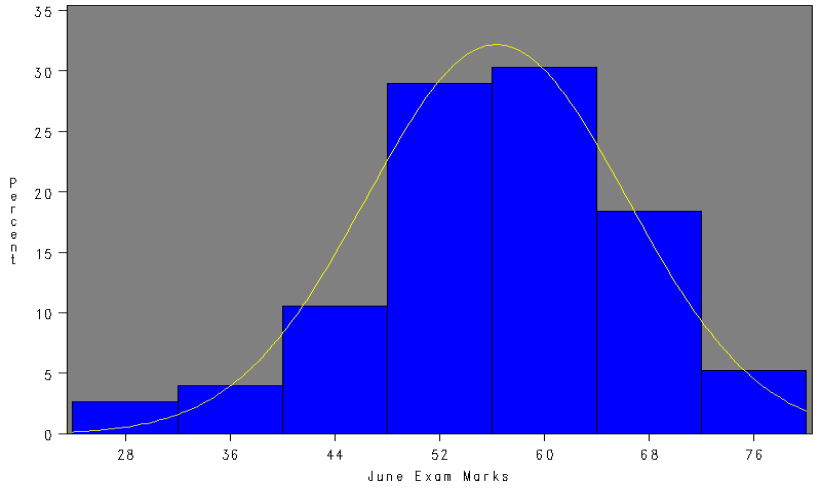
- Testing whether a population correlation is equal to a given value.
- Testing for equality of two population correlations.
- Combining correlation estimates from different samples (Fisher, 1970).

In the case of this report, Eisher's Z transformation served the purpose of testing for equality of two population correlations (males and females).

5.8 Assumptions of Fisher's Z transformation

Figure 5.3 shows that the dependent variable (June examination marks) followed a slightly normal distribution indicating that the assumption of normality was met

Fig 5.3 Assumption of Normality for Fisher's Z transformation



To answer question b, correlations were computed for both the male and female samples, after which Fisher's Z transformation was performed on the correlation coefficients in order to be able to compare them. The results are shown in table 5.7.

Table 5.7 Pearson Correlation and Fisher's Z transformation between Academic Performance & three dimensional spatial perception for males and females

Pearson Correlation Coefficients, Prob> |r| under H0: Rho=0						
	r (three dimensional spatial perception)	**Fisher's Z**	**P-Value**	**r (two dimensional spatial perception)**	**Fisher's Z**	**P-Value**
Males	0.47	0.51	<0.0001	0.39	0.41	<0.0001
Females	0.44	0.48	<0.0001	0.43	0.45	<0.0001

Males N= 190 Females N= 70

Table 5.7 indicates that in the male sample, a correlation exists between three dimensional spatial perception and academic performance (r= 0.47, p<0.0001). The Fisher's Z value for males is presented as 0.51 at a p-value of <0.0001.

For females, table 5.7 also shows that a correlation exists between female's academic performance and their three dimensional spatial perception (r= 0.44; p=0.0001). Females' Fisher's Z value is 0.48 at a p-value of 0.0001. In order to find out if these relationships differed for males and females, Fisher's Z scores were computed in the following equation:

$$z = \frac{r_1' - r_2'}{\sqrt{\frac{1}{n_1 - 3} + \frac{1}{n_2 - 3}}}$$

$$Z = \frac{0.51-0.48}{\sqrt{\frac{1}{190-3} + \frac{1}{70-3}}}$$

$$= 0.21$$

0.21 is less than 1.96; therefore it is not significant at 0.05. This means that the relationship between academic performance and three dimensional spatial perception is not significantly different between male and female students. Thus even though the correlation is higher for male students, such a difference could have occurred due to chance (Blalock, 1960).

Table 5.7 also shows that in the male sample, a correlation exists between two dimensional spatial perception and academic performance (r= 0.39, p<0.0001). The Fisher's Z value for male students is presented as 0.41 at a p-value of <0.0001. For female students, table 5.7 reveals that a correlation exists between female students' academic performance and their two dimensional spatial perception (r= 0.43; p<0.0001). Fisher's Z value for female students is 0.45 at a p-value of <0.0001. In order to find out if

these relationships differed for male and female students, Fisher's Z scores were computed using the equation above and the value yielded was -0.28. This value was also less than 1.96, indicating that the difference between male and female students was not significant at α=0.05.

- **Research Question c.** Is the academic performance of male and female engineering students different? (two independent sample t test)
- **Research Question d.** Are there different relationships between gender, group, two dimensional spatial perception, three dimensional spatial perception and academic performance in students who are receiving special tuition for their difficulties, as compared to the relationships between these variables and academic performance of other students studying the mainstream first year Engineering Graphics course? (ANCOVA).

The researcher also set out to find out if male students performed differently to female students in Engineering graphics, and whether students from the mainstream group performed differently as compared to students in the special course. Table5.8 presents the results for academic performance differences in the special programme, mainstream and all engineering students.

Before discussing the results, however, the assumptions of two independent sample t-tests will be outlined.

5.9 Assumptions of Two Independent Sample t tests

The assumptions for this parametric test include a normal distribution as well as equal variances in the variables (Howell, 1999). From the overall engineering sample, the equality of variance test indicated that in terms of gender and group, the variances for the dependent variable (June exam marks) were equal. In gender, the F test for the dependent variable was 1.01 at a p-value of 0. 92, while group had an F-value of 1.34 at a p-value of

0.14, therefore the equality of variance assumption was met, hence the t-test statistic was performed.

Table 5.8 reveals the results for special programme, mainstream as well as the overall engineering participants. With regards to the special programme sample, there were no significant gender differences in academic performance (males=57.03; females=54.31; p-value 0.30). The mainstream group however showed different results to the special programme. For this group, significant gender differences were found to exist in academic performance. Table 5.8 reveals that for this group, males (61.71) outperformed females (56.52) at a p-value of 0.005. For the overall engineering class, males performed better than females as they had a higher mean (Males 60.29 and females 55.92; p-value=0.005). The table further shows that within the overall engineering class, mainstream participants (mean=60.26) outperformed special programme participants (mean=56.35) at a p-value of 0.01.

Table 5.8 T tests for Gender and Group for Special Programme, Mainstream and all Engineering participants

	Variable	N	Mean	t-value	P-Value
Special Programme Class	Gender: Male Female	 57 19	 57.03 54.31	1.04	0.30
Mainstream	Gender: Male Female	 131 51	 61.71 56.52	2.79	0.005
Overall Engineering Class	Gender: Male Female Group: Mainstream Special Programme	 188 70 182 76	 60.29 55.92 60.26 56.35	2.83 2.59	0.005 0.01

5.10 Assumptions of an ANCOVA

- Multicollinearity: The independent variable should be able to tell the researcher something about the dependent variable over and above what can be accounted for by other variables in the analysis.
- Linearity: The covariate should have a linear relationship with the dependent variable.
- The sample is expected to display a normal distribution.
- There should be a random assignment of participants to the sample.
- There should be at least one categorical and at least one interval independent variable; in other words the covariate has to be interval.
- The dependent variable has to be interval and continuous in nature.

(Howell, 2008)

In this report, the dependent variable (academic performance) generally follows a normal distribution as shown in the previous almost bell shaped graphs. The covariates (two dimensional spatial perception and three dimensional spatial perception) are also interval and the independent variables (gender and group) are categorical in nature.

An analysis of covariance was determined to verify whether there were other influences on the students' academic performance apart from gender (males and females) and group (mainstream and special programme). An ANCOVA allows one to remove from a dependent variable irrelevant or error variance that cannot be predicted from the independent variable. Hence, by accounting for the third variable, one is more able to obtain an accurate picture of the proportion of variance in the dependent variable that independent variable is capable of accounting for; in other words, the power of the results is increased (Cohen et al., 2003).

Table 5.9 ANCOVA for Gender and Group in the Overall Engineering Sample with two dimensional spatial perception as a covariate

	Variable	DF	F-value	P-Value
Overall Engineering Participants	Gender	1, 253	8.23	0.0045
	two dimensional spatial perception		42.84	<0.0001
	Group	1, 253	0.71	0.40
	two dimensional spatial ability		42.84	<0.0001

Table 5.9 shows that even after adjusting for two dimensional spatial ability regarding gender, academic performance still differs significantly by gender (F= 8.23, p= 0.0045). In other words, two dimensional spatial perception has no influence on males' and females' academic performance. Contrasting results are presented regarding group, where after adjusting for two dimensional spatial ability, academic performance no longer differs significantly by group for mainstream and special programme participants.

Table 5.10 presents ANCOVA results with three dimensional spatial perception as the covariate. After adjusting for three dimensional spatial ability, academic performance still differed significantly by gender (F= 7.03, p= 0.0085). From table 5.10, similar results are evident for group, where even after adjusting for three dimensional spatial ability, academic performance still differed significantly by group (F=4.79, p=0.02). This is in line with the results obtained earlier in the backward stepwise regression results, where two dimensional spatial perception was the only variable predictive of academic performance for the special programme participants. One can the deduce from the results that as far as special programme participants are involved, two dimensional spatial perception is the most important predictor variable of their academic performance; and that three dimensional spatial perception is the most important predictor variable for mainstream participants.

Table 5.10 ANCOVA for Gender and Group in the Overall Engineering Sample with three dimensional spatial perception as a covariate

	Variable	DF	F-value	P-Value
Overall Engineering Participants	Gender	1, 253	7.03	0.0085
	three dimensional spatial perception		66.42	<0.0001
	Group	1, 253	4.79	0.02
	3three dimensional spatial ability		66.24	<0.0001

5.11 Summary

- **Research Question a (i)**. Is there a relationship between both two dimensional spatial ability and three dimensional spatial perception and the academic performance of all first year students in Engineering Graphics? (correlation)

Special programme: There was a relationship between three dimensional spatial perception and academic performance for special programme participants (r= 0.31 and P-value is 0.005 in table 5.6). A relationship was also found to exist between academic performance and two dimensional spatial perception in the special programme group (r=0.42; p value=0.0001).

Mainstream Group: A relationship also existed between three dimensional spatial perception (r=0.48; P-value<0.0001) and academic performance as well as between two dimensional spatial perception (r=0.33; P-value<0.0001) and academic performance.

Overall class: There was a moderate correlation between three dimensional spatial perception and academic performance as the r=0.45 and p-value was <0.0001 for the overall class. A relationship was found to exist between academic performance and two

dimensional spatial perception in the overall engineering class, further indicating that both two dimensional and three dimensional spatial abilities are related to participants' academic performance (as indicated in table 5.7 r=0.37; P value <0.0001).

- **Research Question a (ii)**. Is there a relationship between both two dimensional spatial ability and three dimensional spatial perception and the academic performance of all first year students in Engineering Graphics? (Are group, gender, two dimensional spatial perception and three dimensional spatial perception predictive of academic performance?) (backward stepwise regression)

Special Programme: The only significant predictive variable was two dimensional spatial perception at a t-value of 4.06 and a P value of 0.0001. Two dimensional spatial perception accounted for 18% of the variance in participants' academic performance.

Mainstream Group: After a backward stepwise elimination, only gender and three dimensional spatial perception were left in the regression model, indicating that for the mainstream participants, gender (t-value= -3.10; P-value= 0.0023) and three dimensional spatial perception (t=7.56; P-value<0.0001) were predictive of participants' academic performance.

Overall Engineering Class: Group (t=2.10; P=0.03), gender (t=-3.29; P=0.0012) and three dimensional spatial perception (t=8.17; P<0.0001) were found to be predictive of academic performance (table 5.4) while two dimensional spatial perception was not. Together the predictive variables accounted for 25% of the variance in academic performance.

- **Research Question b**. Does the relationship between both two dimensional spatial ability and three dimensional spatial perception and academic performance differ in the case of male and female engineering students? (Fisher's Z transformation).

The results revealed that there was a difference in the relationship between academic performance and three dimensional spatial perception between males and females after Fisher's Z transformation was performed on the correlations but the difference was not significant at $\alpha = 0.05$. Fisher's Z for males had an F-value of 0.51 at a p-value <0.0001, while Fisher's Z for females had an F-value of 0.44 at a p value of 0.0001. The difference could therefore be attributed to chance because the differences that were present were not significant at $\alpha = 0.05$.

- **Research Question c.** Is the academic performance of male and female engineering students different? (2 independent sample test).

  This question was broken down into gender and group; it looked into the performance between males and females and then between mainstream and special programme participants.

Overall Engineering Class: Males and females were found to perform differently in engineering graphics. Males had a mean of 60.29, which is higher than the females' mean of 55.92. The difference was statistically significant as the p-value was 0.05.

Overall Engineering Class: Mainstream and special programme participants performed differently in academic performance. Mainstream participants had a mean of 60.26 while special programme participants had a mean of 56.35, all at a p-value of 0.01.

- **Research Question d.** Are there different relationships between gender, group, two dimensional spatial perception, three dimensional spatial perception and academic performance in students who were receiving special tuition for their difficulties, as compared to the relationships between these variables and academic performance of other students in first year Engineering Graphics? (ANCOVA).

Overall Engineering Participants: For males' and females' academic performance, there was no effect of two dimensional spatial perception as a variable over and above what could be explained by gender. Academic performance still differed significantly by gender even after fixing two dimensional spatial perception ($F=8.27$; $p=0.004$).

There was however an effect of two dimensional spatial perception on group after the adjustment as academic performance did no longer differ significantly between mainstream and special programme participants ($F= 0.71$, $p=0.40$).

5.12 Discussion

In general, with regards to gender, the results in this study revealed that males outperformed females in engineering graphics. Backward stepwise regression showed that gender was one of the significant predictor variables in students' academic performance. The same pattern was also found in two independent t-tests, further revealing that indeed males outperformed females academically.

Similar differences were also evident in the results of tests of both two dimensional and three dimensional spatial abilities, where males outperformed females. These findings thus confirmed the results found in previous studies (Baenniger & Newcombe, 1989; Chan 2007; Voyer, Voyer & Bryden 1995; Quaiser-Pohl and Lehmann 2002) in which it has been reported that males generally outperform females in engineering. This study would suggest that this is related to the fact that male engineering students have better developed spatial abilities than female engineering students, both with respect to two dimensional spatial perception, as well as with respect to three dimensional spatial perception.

By holding the scores on the two dimensional spatial perceptual test constant through ANCOVA, it was found that males still outperformed females and that mainstream participants still outperformed special programme participants. This finding further supported the findings of previous researchers (Baenniger & Newcombe, 1989; Chan

2007; Voyer, Voyer & Bryden 1995; Quaiser-Pohl and Lehmann 2002) that males students perform better than female students in engineering courses. The findings also provide evidence confirming previous suggestions that that students with well developed spatial abilities will academically perform better than those with poorly developed spatial abilities (Potter & Van der Merwe 1982; 1983; 1992; 1995; Van der Merwe & Potter, 2000).

These findings are of particular relevance in providing evidence male students outperform females in engineering, for the reason that male students have well developed spatial abilities as compared to female students. In this study, gender thus emerged as an important predictor of academic performance. When ANCOVA analyses were performed, gender remained significant in all occasions.

Looking at group as a variable (mainstream or special programme), an ANCOVA revealed that two dimensional spatial ability perception had an effect on participants' academic performance. For the special programme participants in particular, a backward stepwise regression revealed that two dimensional spatial perception was the only significant predictor of academic performance. From these findings, one can then conclude that special programme participants have well developed two dimensional spatial perception abilities while mainstream participants have well developed three dimensional spatial perception. As special programme participants were selected for the special class on the basis of poor performance on tasks requiring three dimensional spatial perceptual ability, this finding would again indicate the importance of three dimensional spatial perception in academic performance in Engineering Graphics.

From the results obtained in the study, one can thus deduce that males outperform female engineering students academically for the reason that they have better developed spatial abilities than females; and that students in the mainstream Engineering Graphics outperform students having special tuition in the subject, also for the reason that they have better developed three dimensional spatial perception.

Chapter 6: Qualitative Data Analysis

6.1 Introduction

This chapter presents the results relating to the six research questions presented below. Based on the research design discussed in the methodology chapter, the first of these questions will be answered in this chapter by using data drawn from interviews conducted with a sample of 18 female Engineering students. This will be contrasted with data drawn from a matched sample of 18 male Engineering students. In the next chapter, an integration of trends from these analyses and the previously presented quantitative analyses will then be attempted. This will be done by focusing on the coping strategies adopted by female students with poorly developed three dimensional spatial perception, as well as by contrasting data from the female students with data drawn from the male Engineering students in the sample.

6.2 Research Questions

- **Research question Two**. How do female Engineering students cope with their studies?

6.3 Content analysis to address Research Question Two

To answer research question two, a content analysis was conducted. A series of directed questions were used as a framework for the analysis, as follows:

- a. What strategies are used by female Engineering students in making the transition from school to university?
- b. Are similar strategies effective in studying all first year Engineering subjects, or are different strategies necessary in studying Engineering Graphics?
- c. Do male Engineering students use similar strategies to female students in coping with the demands of their first year courses?

- d. What coping strategies are necessary for female Engineering students who have poorly developed two dimensional and three dimensional spatial abilities as opposed to well developed two dimensional and three dimensional spatial abilities?
- e. Are these strategies similar to those adopted by male Engineering students with poorly developed two dimensional and three dimensional spatial abilities as opposed to males with well developed two dimensional and three dimensional spatial abilities?

- f. Are there other influences on the students' academic performance, and are they similar for males and females, as well as for students receiving special tuition for their difficulties, versus those in the mainstream programme?

6.4 The Type of Content Analysis Conducted in this Study

6.4.1 Thematic Content Analysis

Thematic content analysis is one of the widely used methods of content analysis. Thematic content analysis is a process of encoding qualitative information in which the encoding requires an explicit code which may be a list of themes or indicators that are causally related. It is a term used to describe a method of content analysis in which themes are identified, categorised and elaborated based on a systematic scrutiny (Boyates, 1998). A theme is defined as "a pattern found in the information that at minimum describes and organises the possible observations and at a maximum interprets aspects of a phenomenon" (Boyates, 1998; Braun & Clarke, 2006). Themes can either be manifest (directly observable in the data or latent (underlying the phenomenon) and may be generated inductively from the raw data or deductively from theory and prior research. Kerlinger (1964) however argues that as much as a theme is a useful unit of analysis because of its closeness to the original content, it is usually very time consuming to code.

6.5 Method of Theme Extraction

The method of theme extraction involved several stages. First the data were arrayed such that the right hand margin was created on the right hand side of the page. Secondly, the data was read as a whole, writing a set of preliminary codes or themes on a separate sheet of paper. These were given names of about three phrases to summarise major themes found in the data.

Because the researcher conducted structured interviews using an interview schedule, a number of preliminary codes were formed by writing a short phrase which summarised the theme underlying each question in the interview schedule. After this, the data were then examined by reading each interview transcript sentence by sentence, scanning for each sentence's underlying meanings. The meanings that matched the preliminary codes were then recorded as codes on the right hand column indicating that that particular theme had been found in that particular sentence. The next code was then looked at in relation to the sentence as it was possible for a single sentence to be matched to two or more codes. Then the researcher moved to the next sentence, after ensuring that there were no hidden themes in the sentence.

6.6 Results

The interviews with the female students were first transcribed, after which a sequence of recurrent themes were extracted in relation to the theories presented in the literature review. The researcher then analysed the data from the male students in a similar way.
Data from all 36 interviews were then combined to identify recurrent themes within the interview data as a whole. The researcher then analysed the interviews for a second time with the purpose of verifying the themes found in the first analysis. The themes from this verificatory analysis were then used for reporting the results. In reporting themes from the analysis, quotes were cross-referenced by letter and number back to the researcher's original transcripts. The themes from the interviews with the female and male students were then compared, and a matrix of agreements and disagreements created (Appendix One).

6.6.1 Research Question One - How do female Engineering students cope with their studies?

Sub Question a: What strategies are used by female Engineering students in making the transition from school to university?

In order to answer sub question a., in the interview schedule participants were asked two questions namely how they studied for Engineering graphics and how women could be helped to adapt to university life.

Study Methods in Engineering Graphics

Four themes emerged; these were reading alone, studying in groups, adopting both methods and no method of study. The majority preferred to study alone [B3, BB3, C1, CC1, DD1, FF1, F1, I5, II3, J5, JJ3, N4, NN3, QQ3, R4, RR4, EE6, G5, GG6, KK5, LL5, MM4, P4].

Reading Alone

> B3: "I just do most of the stuff during the tut; I do that by myself. And then for the test I just go through what we did in class, and to see how these work and where, what you supposed to do. Because I find if you do the work yourself, it's, you just understand better what's going on."

Four of the participants showed that they do study in a *group* [O4, PP3, Q2, M4]. In discussing how she studies for graphics, this is how O4 expressed herself:

> O4: "Well I usually ask one of my friends who've done TD at school. Like lots of the guys have done TD at school, so they usually help us ya."

Six other participants [AA3, HH3, K4, OO3, D4, L4] showed that they found adopting *both* methods helpful when studying for graphics while one female showed that she did not study for Engineering graphics. In support of this are K4's and A3's statements:

K4: “I study on my own and sometimes with my friends. Uum I usually do it on a Sunday when I have more time and I just get books from other people doing graphics. And I try and do my best and I ask someone who is doing graphics to check my work, and if it’s correct I carry on.”

A3: “Um, for Graphics I don’t really study, I go over the problems an hour before or like the night before.”

Ways to Help Women Adapt from School to University

There was also quite an array of themes in the data relative to this issue, although the researcher gained the impression that many participants appeared not to know how they could be helped to adapt to university. It could be that they did not understand the question or they really had no ideas at all, because most of them showed that they were still adapting themselves, that they had not fully adapted to university life. However, some did manage to give a number of suggestions, which are presented below.

Extra Tutorials [C4, R4]

R4: “Uum, [pause] I don’t know, maybe they should be given some extra time to discuss the issues.”

I: “What do you mean by extra time?”

R4: “I think they should be given extra tutorials.”

C4: “Hm, I find tutors in like all tuts and stuff very, very helpful, so I ask questions, so maybe if we could have more of them, if they could be readily available.”

Guidance from Senior Students [Q4]

Q4: “I think we really need guidance from people whoa re doing fourth year; to guide us to know that this is the environment. We didn’t come here to enjoy, we just came here to study.”

Change of Mindset [HH3, OO3, PP4]

PP4: "It just depends on what type of a person you are. If you are those types of people who think of a challenge as a disaster and not those types of people who think of a challenge as an opportunity, then you're bound to get difficulties. If you aren't those types of stereotyped people telling you that it's difficult when you get to varsity, then when you get to varsity you really think that it is difficult."

Hard Work [BB4, JJ3, O4]

O4: "…you have to work harder and that things aren't gonna just be given to you like it was at school."

Special Programme [K5]

K5: "I actually like the special programme coz at first I didn't wanna go into it , but then it was like no, I'm failing I need help. So first of all we have to accept help, second of all this programme should be enforced. Instead of four year programme, it should be a five year programme."

Responsibility [AA4, I4]

I4: "Hm. It's all about I guess with all these things going on around you, you have to be able to say to yourself, ok my mother and father are not here. I'm responsible for me and my finances. It's me, everything is just me. Once you've accepted the fact that it's just you, then you'll learn to discipline yourself."

Counselling [FF3]

FF3: "Uuh eish, for us like I, in mining, we've got like, eish, I could say we are truly special unlike some of the students from electrical and everything. We have career advisors, we have the CCDU, so if you use all the resources then it will be easy for you to adapt."

Time Management [CC3, DD3, E4]

CC3: "I just basically told myself it's ok. This is it, I'm here, might as well get it over and done with it. You know DIM [Do It Now]."

Self-Motivation [B4]

B4: "I think people who work hard at school will work hard at university. But it's hard; it's difficult for people who never worked hard at all to find it easy to start working. And I believe will power is probably the only thing that will, because going through physically going through the stuff."

Preparation from School [J6, N5]

J6: "the best thing to do is to go to the high schools like when they are doing grade 11 and grade 12, and then people should go there like social workers, some people are responsible about people. They should go there and talk to them about different styles about Engineering.

Keeping up with Work

A4: "… to keep up with the work and to keep yourself going, to keep working in the evening is quite difficult. But I think it depends on how motivated you are to keep you going. If you motivated you will be able to pull through I think."

Competition

D5: "…the thing that really drives you is the competition, you want to beat everyone up, and to your marks and your pride, well it's the same thing."

Independence

H4: "I, I don't know. I think it depends on the person. You learn, you learn because no one can tell you what works for you. You find out stuff for yourself."

O Week

> L5: "I like the idea of orientation week, you get introduced to things… maybe we could change it to a more motivational kind of thing; like it's gonna get hard, but you can do it, instead of destroying our little souls. You know it may be helpful. You know senior students can be so negative at times…The say things like "you going to fail, Wits gives you the edge, what what what" you know."

6.6.2 Sub Question b: Are similar strategies effective in studying all first year Engineering subjects, or are different strategies necessary in studying Engineering Graphics?

This question was addressed by looking into study methods used by the participants when studying for other subjects. The results are presented below.

Study Methods for Other Subjects

> In studying for Engineering graphics, most participants showed that they preferred to work alone. The same discovery was also made regarding studying for other subjects. Eighteen participants preferred studying alone [AA3, B3, BB3, C3, E3, F4, I5, II3, J5, JJ3, N4, NN3, O4, OO3, PP3, QQ3, R4, RR4, A3, D4, EE6, GG6, KK5, L4, M4, MM4]. In her discussion, O4 showed that the only way one could understand physics and maths was by reading through the notes; "Obviously like reading through notes. And then doing problems, which is the only way you can like do physics and maths" [O4]

Five participants preferred group work [C3, DD3, HH3, P2, H3] while four [FF3, K4, G5, LL3] preferred both methods of study. Most participants were showing that subjects on which they study in groups were maths and physics because they found those subjects difficult. Some of these expressions are given below.

Group

HH3: "And again when I'm studying I make it a point that we study in groups, so that if someone doesn't understand what we are doing, maybe there can be other people who are gonna help."

Both

FF3: "Like for physics, I usually do it with my friends because eish! It's giving me a hard time. But fro some of them I still study alone."

K: "Uum, I usually study alone at first. For example Maths, I make sure that what I did today, I make sure I review and try to understand. If I'm stuck on a question I usually go four floors up, we knock on each others' door. And every Sunday there's three of us who live at res, we meet together if there's any problems within any subject, that includes Chemistry and Physics."

6.6.3 Sub Research Question c: Do male Engineering students use similar strategies to female students in coping with the demands of their first year courses?

Table 6.1 Study Methods by Gender and Group

Engineering Graphics			Other Subjects	
Method of Study	Male	Female	Male	Female
Reading	14	10	14	12
Group	2	3	2	2
Both	3	3	1	2
None	-	1	-	-

The answers to this question were also determined by asking participants what method of study they used for graphics as well as for other subjects. It was discovered that there was not much of a difference in the methods adopted by the participants. There were slight differences regarding to studying for graphics, where 10 females preferred reading while

14 males also preferred reading. The difference was not that large. Only 3 females showed that they studied in groups while 2 male indicated this. 3 males adopted both methods and three girls used both methods.

Study Methods for other subjects had two slight differences regarding the themes of reading and adopting both methods of study. 14 males preferred reading while 12 females used this method of study. 2 females adopted both methods of study and 1 male used this method.

6.6.4 Sub research question d: What coping strategies are necessary for female Engineering students who have poorly developed two dimensional and three dimensional spatial abilities as opposed to well developed two dimensional and three dimensional spatial abilities?

To get answers to research question d. participants were asked to suggest ways in which first year female Engineering students could be helped to improve their performance in Engineering graphics. The opinions given are presented below. The matrices of agreements for opinions given by mainstream participants and special programme participants are also illustrated in appendix two.

Strategies to Improve Women's Performance in Engineering Graphics

Participants gave quite a range of suggestions as to how women's academic performance in Engineering graphics could be improved. The array of opinions is presented below.

Special Programme [A1]

> A1: "Um, I'm not sure. The special programme is definitely really good. But there's too much English and stuff in that special programme."

Study Groups [G6]

> G6: "[laughs] By study groups."

Confidence [D4]

D4: “Uum I know where I went to school you know it was like ritual to stand up for your rights. And to I mean, most of the girls at my school were feminists. No one could walk over us. If they get taught that they really are at the same level as men and not as the weaker man, ok not as the slower people. They are really, you know, they are at same level. They can push as much as uum, they really can go forward. And if they get taught that, then I’m sure things will be better.”

More Lectures and Tutorials [H4, Q4,PP4, HH3]

H4: “I think we should get more time in class. You know when you learn you think, sometimes you just don’t get the concept and you just do it for like 20 minutes and then the lecturer is gone. And then you’re stuck. At least if they had like extra tutors to kind of help.”

Q4: “I think if we can have extra tutors, and even extra classes, and then like for the mainstream one; where they are doing mainstream, they are having one class and one tutorial. If we can have a class and more tutorials than anything, some of the tutorials we are not supposed to get marks for them, we are just supposed to ask and to understand what’s happening. If they can do that I think it can be better.”

PP4: “I don’t know maybe two tutorial sessions a week; something like that.”

Orientation Week [L5, FF3]

L5: “I like the idea of orientation week, you get introduced to things.”

Technical Drawing at Schools [M5, O4]

M5: "I think first of all, like they must first teach like, er, teach them some of the stuff while they are still at school in matric or during the holidays, I mean the December holidays."

O4: "I think first of all a lot of all girls' schools in Durban don't offer TD, I think they should offer that definitely! And uum also like I know a lot of the females have more of a problem with physics than they do with maths, and I think maybe more work should be done on the physics part at school.

Break Down Stereotypes [MM5]

MM5: "I think that there is… looking at the questionnaire, there are a lot of perceptions of women in Engineering and I think some of those need to be broken down for women to really succeed in Engineering. I mean I think they have the potential to, definitely. But I think they are sort of regarded as second class in the Engineering sector, and I think that makes them succeeding in the Engineering sector much more difficult."

Do Away with Gender Classification [P4]

P4: "The thing is the real reason that we are not doing well is we come here knowing that this is for men and not for women, so I can't do it. If you tell your mind that you can do this, then you just gonna do it."

Slower Mathematics Lectures [EE4]

EE4: "Well I thought like in Maths, like the lecturers could have gone like a little bit slow coz… I… they have like a time frame like they have to do some target. They rush through everything…"

Teach Women Confidence from School [KK4]

KK4: "About women from school to university? I think there is a big jump. I think the main thing from school is just (coughs), you need to be all independent.

What I mean by that is uum, they (at school) need to give you more work, and you need to do it yourself, coz a lot of the time in class they give you the work that the teacher has done; you're not doing it yourself."

Responsibility [LL4]

LL4: "Uum because in performance… are you willing to work as you should? Engineering is seen as a tough course. I think it's possible…if you…you don't have to be top student in order to get through Engineering. You just have to be prepared to go through the work… I think a lot of the guys who fail or who perform badly are not stupid at all. They are quite capable; they just don't go to lectures or do the required work."

Change of Mindset [BB3, K5, R4, GG6]

R4: "I don't know if anyone can help except for that person. I think it's from the person's mind to say I want to do this and I will do it."

Motivation [OO3]

OO3: "Uum I know some of my friends are not doing well due to a lack of effort; they are quite smart. Maybe motivation, I don't know people seem to be bored at some stage. Apart from that if people are really trying and they are struggling, perhaps we could arrange for example physics is a big problem for most people, perhaps if they could introduce more physics tuts. The physics tuts aren't really interactive. You sit there and you do what you like basically."

Preparation from School [N3, J6]

N3: "Well I've noticed that at school uum, you are taught how to pass matric, but when you get here it's, it's a whole different, you know, universe because it's another way of doing things. Here you have to think, you have to analyse, you have to do a whole lot of things you never did in matric. So uum at school, maybe if they can just make uum, maybe the, the, the, maybe…"

I: "Prepare you guys?"

N3: “Yes! For university because this is a difficult world. It’s a very difficult world, you face things that you never thought you were gonna face, and uum, you end up finding yourself stressed…”

Improved Lecturing [II3, JJ3]

JJ3: “Uum, I think the course should be, like err extra help should be provided. Like ok in the tutorials the tutors do help, but there’s no point in giving us a tutorial for three hours learning how to do it and the trying to complete the exercise for marks, coz by the time you’ve learnt how to do it you’ve already wasted half the time. So if you don’t have enough time to finish the thing you gonna fail the tutorial.”

I**:** “So more explaining?”

JJ3**:** “Ya and more practical exercises in class.”

II3: “You know what, in mainstream we didn’t have extra lectures but I’ve realised that it’s; now in special programme we got more lectures and tutorials, so if, if…in mainstream let me tell you something. In mainstream they just tell you. They don’t do things in detail. They just brush and let it go, but now they do it in detail so my suggestion is that they should dwell in one thing not in a short period of time. They must do it in detail so that people can understand coz we are not the same.”

Counselling [I6]

I6: “First of all they should be sat; you should sit them down and ask them, are you really sure this is what you want to do?

Interviewer: As in before registering?

I6: No. As in, you know after the first six months of the course, you can feel if this is really where I want to be or this is not where I want to be., coz some people just stick it out coz they say ok I made a choice for this course and then I’m gonna stick it out until they exclude me or whatever...”

Hard Work [AA3, DD3, F4, RR4]

F: "Umm, through work. Because like in Engineering, most people are just laid back they don't really work."

Individual Tutors [E4]

E: "I think individual tutors can help… you just get to…like somebody who you ask and then the person is going to be patient and all that."

Extended Curriculum [B4]

B: "You know what, I think most, a lot of people who do badly, it's just because they don't study. They don't do anything. But I think the people who are not doing well, who actually do study, I believe, if, like the extended programme. I know a lot of people uum, failed maths, and that's why they had to go on an extended programme, but I know at other universities the extended programme they still do the full course of maths, but other varsities they do first year maths over two years. If the maths would be spread over two years, it makes it a lot easier because it is a difficult subject. So instead of having one week spent on this particular problem of math, you have two weeks in which you can understand and get to terms with everything."

Looking at the suggestions given above, one can deduce that most participants believed that improvement of women's performance as well as students in general is their own responsibility. This is evidenced by suggestions such as taking one's responsibility for their studies, change of mindset, with a number of them suggesting hard work. It was also apparent in the extractions that apart from having difficulties with graphics, many participants were struggling with mathematics and physics, as indicated by OO3, O4 and B4.

Research Question e. Are these strategies similar to those adopted by male Engineering students with poorly developed two dimensional as well as three dimensional spatial ability as opposed to well developed two dimensional and three dimensional spatial ability?

Table 6.2 Strategies suggested by special programme males as compared to those suggested by mainstream males

Mainstream Males	Strategies	Special Programme Males	Strategies
QQ3, LL4	Responsibility	CC3	Responsibility
RR4	Hard Work	AA3, DD3	Hard Work
PP4	More Lectures and Tutorials	HH4	More Lectures and Tutorials
JJ3	Improved Lecturing		
OO3	Motivation		
KK4	Teach Women Confidence from school		
MM5	Break down Stereotypes		
		EE4	Slower Maths Lectures
		BB3, GG6	Change of Mindset
		FF3	O'Week

Table 6.2 presents the strategies suggested by male participants from both the mainstream and the special programme groups. The strategies suggested are different, with three

common methods of improving academic performance. Males from the two groups felt that it was their responsibility to excel in the course, that they had to work hard and that it would be beneficial if more lectures were provided. Table 6.2 also shows that mainstream males and special programme males also had different suggestions regarding coping methods. Mainstream males showed that improved lecturing, motivation, confidence in females and removal of stereotypes were necessary in order to help students cope with their studies. Special programme males on the other hand, suggested slower maths lectures, change of mindset and being briefed about the course during orientation week.

Table 6.3 below presents the strategies suggested by female participants from the two groups. The theme of stereotypes appears once again in the fact that mainstream males suggest that serotypes should be done away with in engineering. It is also evident that that low efficacy is there in females because one of the males is suggested that females must have confidence in themselves in order for them to cope with their studies.

Table 6.3 Strategies suggested by mainstream females as compared to those suggested by special programme females

Mainstream Females	Strategies	Special Programme Females	Strategies
F4	Hard Work		
H4	More Lectures and Tutorials	Q4	More Lectures and Tutorials
B4	Extended Curriculum		
E4	Individual Tutors		
I6	Counselling		
A4	Special Programme		
D4	Confidence		
G6	Study Groups		
		K5, R4	Change of Mindset
		L5	O'Week
		J6, N3	Preparation from

			school
		O4, M5	Schools should offer technical drawing
		P4	Remove Gender Classification

From table 6.3, it is clear that mainstream girls and special programme girls suggested **different** strategies to improve the academic performance of females with poorly developed two dimensional and three dimensional spatial abilities. The only suggestion they had in common was that of having more lecturers and tutors. Table 6.3 shows that mainstream females felt that hard work, an extended curriculum, individual tutors, counselling, special programme, confidence in oneself and study groups were key to improving their performance in engineering graphics thus making it easy for them to adapt to university life in their first year of engineering. Special programme females on the other hand, showed that in order to cope with their work, they opted for change of mindset, being briefed about the course during orientation week, preparation from school and removal of gender classification in engineering.

Relating back to the literature review, it was mentioned that self-efficacy and stereotype threat theories played a major role in students' academic performance in engineering graphics. One of the suggestions made by mainstream males is that of confidence in oneself in order for one to excel in the course (Hackett & Betz, 1981; Steele & Aronson, 1995). It is therefore not surprising that mainstream males suggested this as they would feel more confident especially because they have better spatial ability due to the way they were socialised and exposure to engineering related courses. Females on the other hand, would remain more mundane and not so ambitious to excel in engineering as according to self-efficacy theory, they have mainly been socialised to be housewives and the like (Hackett & Betz, 1981).

Research Question f: Are there other influences on the students' academic performance, and are they similar for males and females, as well as for students receiving special tuition for their difficulties, versus those in the mainstream programme?

There were indeed other influences to students' academic performance apart from spatial ability. Opinions given in relation to this question were not that varied for males and females, nor were they varied for mainstream and special programme students. They seemed to be more or less similar and some of them are shown below. These were also in line with some influences identified by Kaufman (2000) in her research and they included previous experience, cross-cultural differences and gender issues from the content categories (Kaufman, 2000).

School one attended L1 (Previous Experience)

L1: "Because other schools do not offer technical drawing coz it's an expensive subject. If the equipment is not available at school they don't do technical drawing, so when you start engineering graphics it's hard [laughs]"

Method of teaching II:2

II2: "In the first semester I was in mainstream but the person who taught us was not good enough. She was like err, just, just err, she was not teaching in detail. She was just showing you one example, but now we got better tutors and lecturers so it's a bit easier now."

Stereotypes F2:

F2: "the engineering right now is towards men. Most of our labs are like gear boxes, engines and stuff, and I've never seen an engine in my life. But then I'm coming here and

I have to adapt, but the guys are finding it easier doing engineering than girls, and it does affect the way they perform…"

Upbringing G2 (Cross-cultural differences)

G2: "…like when we were growing up we were told that engineering is only for men; we as women we are weak we don't have that power and we are not strong to do the work they do; we gonna need somebody to lift some things for us. So we are not supposed to go there, like we only need to work in offices."

6.7 Summary

The main question of the chapter was to report on how first year female Engineering students coped with their studies and the methods they adopted were compared with those adopted by their male counterparts. It was found that female Engineering students used three main methods of study both for Engineering graphics and for other subjects. These were reading alone, studying in groups and using both methods of study. However, it was evident from some of the students that when approaching other subjects, it was important to understand the concepts very well, whereas Engineering graphics needed a lot of practice with three dimensional drawings. It was also discovered that males and females did not differ that much in the methods of study used in coping with demands of the course. Furthermore, the suggestions participants gave were not that different, as is seen in the matrix of agreements (appendix one) for suggestions on how women can be helped to adapt from school to university. There were agreements on having slower mathematics lectures, working hard, change of mindset towards the course, briefing about the course during orientation week as well as more lectures.

Chapter 7: Integration Chapter

7.1 Introduction

The purpose of this chapter is to examine the quantitative findings through the lens of the results found through the qualitative analyses; to link together the major themes both from the quantitative chapter and the qualitative chapter and attempt to make sense of them. This will be achieved by examining certain core themes from the quantitative and qualitative analyses, against certain major issues which have been identified from the literature as likely to affect the academic performance of female Engineering students and how they cope with university.

7.2 Quantitative and Qualitative Findings: Core Themes and Issues

7.2.1 The Majority of First Year Female Engineering Students have Spatial Perceptual Difficulties

From the quantitative analyses of the data, one of the major issues that emerged was that female Engineering students have spatial perceptual problems. In comparison with the female students, male Engineering students were found to be doing better than female students on tests of three dimensional spatial perception. Male students also performed better than female students in the June examinations.

The quantitative analyses presented in Chapter Five were thus of particular relevance in providing evidence that male students outperform females in Engineering, for the reason that male students have well developed spatial abilities as compared to female students. In this study, gender thus emerged as an important predictor of academic performance, as when ANCOVA analyses were performed, gender remained significant in all occasions.

7.2.2 The Majority of First Year Female Engineering Students have Low Career Self Efficacy

There have been previous references in the literature to gender issues in Engineering (Swim, 1996; Quaiser-Pohl & Lehmann, 2002; Baenniger & Newcombe, 1989; Bem, 1981; Martin &Halverson, 1981) and the data from this study also yield a number of indications as to the reasons why males Engineering students outperform female students at first year level. The quantitative data indicate that one reason for this is that male first year Engineering students have better developed three dimensional perception. In addition the qualitative data indicate that male first year Engineering students have better self-efficacy.

In a number of the interviews conducted with the female students, there were themes of low self- efficacy. These include D4, O4, Q4, P4, R4. Some male students (MM5, LL4, KK4) also expressed the opinion that females had a low self-efficacy when it came to excelling in Engineering graphics. These students commented that females lacked the confidence that they could excel in the course. This theme was particularly evident in KK4's excerpt.

It was thus concluded that the idea of female students possessing low self-efficacy regarding Engineering was broadly held among the first year Engineering student body, as indicated in the following themes extracted from the interviews:

> D4: "...If they get taught that they really are at the same level as men and not as the weaker man, ok not as the slower people. They are really, you know, they are at same level. They can push as much as uum, they really can go forward. And if they get taught that, then I'm sure things will be better."

> O4: "I think first of all a lot of all girls' schools in Durban don't offer TD, I think they should offer that definitely! And uum also like I know a lot of the females

have more of a problem with physics than they do with maths, and I think maybe more work should be done on the physics part at school."

P4: "The thing is the real reason that we are not doing well is we come here knowing that this is for men and not for women, so I can't do it. If you tell your mind that you can do this, then you just gonna do it."

KK4: "About women from school to university? I think there is a big jump. I think the main thing from school is just (coughs), you need to be all independent. What I mean by that is uum, they (at school) need to give you more work, and you need to do it yourself, coz a lot of the time in class they give you the work that the teacher has done; you're not doing it yourself."

At the same time, amidst all these beliefs of low self esteem among females, there were some elements of some hope and belief. Some of the female students believed that they could stick it out and do their best, as shown in the excerpt below:

I6: "…you can feel if this is really where I want to be or this is not where I want to be., coz some people just stick it out coz they say ok I made a choice for this course and then I'm gonna stick it out until they exclude me or whatever..."

The findings from the qualitative analyses also indicated that female Engineering students used three main methods of study both for Engineering graphics and for other subjects. These were reading alone, studying in groups and using both methods of study. However, it was evident from some of the students that when approaching other subjects, it was important to understand the concepts very well, whereas Engineering graphics needed a lot of practice with three dimensional drawings. It was also found that males and females did not differ that much in the methods of study used in coping with demands of the course. Furthermore, the suggestions participants gave were not that different, as is seen in the matrix of agreements (Appendix One) for suggestions on how women can be helped to adapt from school to university. There were agreements on

having slower mathematics lectures, working hard, change of mindset towards the course, briefing about the course during orientation week as well as more lectures.

What was chiefly evident across the data as a whole was that male students were generally far more confident than female students and felt that they were better able to cope with the tasks they were given in the first year Engineering Graphics course. While male students in the special course expressed some misgivings about their ability to cope with the particular type of tasks they had to cope with in Engineering graphics, the comments made by the female students appear to be far more general. They appeared to relate to fears about coping with Engineering as a career for which they were unprepared as well as fears about coping with Engineering graphics as a course, in which they were presented with many tasks they found difficult.

This study would thus substantiate the work of previous researchers in the field (Swim, 1996; Quaiser-Pohl & Lehmann, 2002; Baenniger & Newcombe, 1989; Bem, 1981; Martin &Halverson, 1981) who have indicated that there are gender differences which affect the academic performance of first year Engineering students. The findings of this study would also provide a theoretical basis for suggesting why these gender differences are found.

The qualitative data from this study produced clear indications that one of the major factors underpinning gender differences among Engineering students is self efficacy. According to self-efficacy theory, one's cognitions determine the way one acts (Bandura, 1977). This theory suggests that changeable cognitive factors such as self-perceptions and expectations of success have a significant impact on one's motivation and achievement (Ochse, 2001). It was further postulated in this theory that females are socialised more towards becoming house wives than engineers, hence the reason so few of them have pursued careers in technical fields related to Engineering (Ochse, 2001).

Career self-efficacy theory would then suggest that if a woman has high self-efficacy beliefs, she will do well in Engineering at university and maintain her excellence in

Engineering courses and vice versa (Hackett & Betz, 1981). The poor academic performance of females could therefore be ascribed to the fact that due to the low self-efficacy most females possess, a lot of them do not even aspire to excel in Engineering because they already believe that they are not capable of doing well in the course.

7.2.3 Stereotype Threat affects the Decisions of Female Students to Follow Engineering as a Career

In addition to low career self-efficacy, stereotype threat emerged as another major factor linked to female students' low academic performance and the difficulties they experience in Engineering graphics. Stereotype threat refers to the state of being at risk of confirming as self-characteristic, a negative stereotype about one's group (Steel & Aronson, 1995; McGlone & Aronson, 2006). The idea that self-efficacy and stereotype threat theory play a role in the students' academic performance in Engineering graphics is evidenced quite nicely in the qualitative section of the report, where interviews with participants revealed that indeed these two issues influenced participants' academic performance.

During the interviews, it was evident that most females saw themselves as the other group; and in particular as a group that performed badly in Engineering graphics because they were not as skilled as their male counterparts. Of interest, is the fact that many male Engineering students felt that women could still do well in Engineering graphics, although there were some who also held the view that females could never excel in Engineering graphics. Some of the students who raised this issue of stereotyping included HH2, D5, P4, N2, F2, E2, O2, Q2, I3, KK2, EE2, BB2, AA2, QQ2, RR2 and DD2. Broad themes evident in these interviews indicating that stereotyping was present were as follows:

- Female students need to strive to do well just so that they can prove to themselves and their classmates that they can do better than males
- No matter how hard they work, female students cannot outperform males as Engineering is a man's world after all.

- If they work hard enough, women can do well in Engineering.

7.2.4 Themes indicating stereotyping as viewed through the eyes of Females

These will be divided into the sub-themes already mentioned above.

- **Female students need to strive to do well just so that they can prove to themselves and their classmates that they can do better than males**

D5: "…the thing that really drives you is the competition, you want to beat everyone up, add to your marks and your pride, well it's the same thing."

P4: "The thing is the real reason that we are not doing well is we come here knowing that this is for men and not for women, so I can't do it. If you tell your mind that you can do this, then you just gonna do it."

N2: "Uuh when coming to women in Engineering, well I figured something out; your mind works in another manner, coz sometimes what you put in there, it sticks in there and then if somebody is gonna tell you something like that, even though you are gonna do it, but it's still at the back of your mind. It's, it's still gonna affect you. But women in Engineering, I think they doing fine. Even though there are some that don't trust their abilities and strengths uum because they've been told Engineering is for men, but still they not uum, they are not incapable of that…because…unless it's somebody who…I think it depends on what somebody really wants."

- **No matter how hard they work, female students cannot outperform males as Engineering is a man's world after all.**

Some females showed that it was very discouraging to try and do well in the course, as it was already believed that females could never perform better than males. They themselves also felt that males are at an advantage due to their lifestyles and upbringing for reasons such as being exposed to car engines at an early age, as shown in the excerpts below.

F2: “I do think that um, the Engineering right now is towards men. Most of our labs are like gear boxes, engines and stuff, and I’ve never seen an engine in my life. But then I’m coming here and I have to adapt, but the guys are finding it easier doing Engineering than girls, and it does affect the way they perform… because they have an unfair advantage that they have a better chance of doing well and so then like I’m not gonna wanna push harder because I know they’ve already got that advantage. But then on the other hand it does make me wanna push harder to do better and to show them that as a girl I can also become an engineer.”

E2: “we have male tutors for physics and graphics tuts; oh ya we had a lady tutor the first semester but this semester it’s only males [smiles] So sometimes you ask yourself how did they get there. Is it like they choose the gender or is it like ladies can’t get there or something? Ya sometimes there is that stereotype ya.”

- **If they work hard enough, women can do well in Engineering**

  Other females were of the opinion that even though this course is popularly known as a male course, if women are determined enough; they could excel in the course. They also believed that just because it is believed to be a male dominated course then women cannot do well in the Engineering.

O2: “Uum, I think that some of them (stereotypes) are a bit extreme because when I tell people that I study Engineering they give me that wow!, why are you doing that? But I think that women are becoming a lot more empowered and they are taking on the Engineering field.”

Q2: “I don’t think they do exist anymore, coz we as women now we can do better in Maths and Science. And even though it’s believed that Engineering is for men, even women can do better in that field. Coz it’s like, here at Wits we’ve got more girls who are doing Engineering than guys; I mean in our civil class.”

I3: “you look at it like most of our lecturers are men, and they had this thing that if you don’t have the physical power you probably can’t do it. But it’s not like that coz you can do Engineering while you are a woman, it doesn’t mean; Engineering is all about making… how much power you use like easier, not using a lot of power. So mean c’mon, we can do it. If a man can do it I can do it. That’s what I think.”

7.2.4 Themes indicating stereotyping as viewed through the eyes of Males

Contrary to the themes that emerged during females’ interviews, males seemed to have a positive outlook regarding women’s performance in Engineering graphics. Themes that emerged include:

- Women can perform better than males in Engineering
- Women cannot outperform males in Engineering because they are not designed for Engineering.
- No matter how hard they work, female students cannot outperform males as Engineering is a man’s world after all.
- Stereotypes in Engineering do not exist.

- **Women can do better than men in Engineering**

KK2: “I don’t think so. I think a woman engineer would do a lot better than a male engineer….I don’t know, because there are so few of them…so they would.”

I**:** “They would strive to do better?”
KK2: “Yah. Exactly.”

EE2: “I don’t think they are right because women are just as clever as men. And, ya even in class they know what’s going on sometimes better than, most of the times better than, than…”

I: “Men?”

EE2: “Ya.”

BB2: “Uum I think those stereotypes are there, I don’t think… I think yes it might affect women’s performance, but I don’t think it would affect negatively. I think it would strive women to prove themselves more.”

AA2: “Engineering is more like a degree where you have to be creative and I find that usually women are more creative than men, so I personally disagree with the stereotypes because some of the women in my class actually do much better than the guys. And basically Engineering is for all.”

- **Women cannot outperform males in Engineering because they are not designed for Engineering.**

QQ2: “No, some of them exist ya, but I think, women are, I don’t think they are mentally trained for Engineering; mentally and physically. Because you find some of them, most o the time, most people who are struggling with drawing, are women, even with design. I don’t know what is the problem with them but I think they are lazy to think maybe or something like that, coz they always like want people to help them.”

There was one theme that was common between males and females, and that is the belief that females could never outperform males in engineering graphics.

- **No matter how hard they work, female students cannot outperform males as Engineering is a man’s world after all.**

RR2: “many male students don’t think that female students can be good in Engineering, so the girls are somehow discouraged to do well. For example if you can check like in the third and fourth year I don’t think there are many females there. In the first year we do have many of them but like they drop out as time goes on.”

- **Stereotypes in Engineering do not exist.**

This theme was very common amongst male students, where they believed that such stereotypes that females could not perform as well as males did not exist anymore. What is interesting is that overall, males had a more positive outlook than females about females' performance in the course, which makes one wonder whether they were genuine or that they were driven by the fact that the interviewer was a female and therefore they did not want to offend her.

DD2: "I think they don't exist and they are not true because almost 50% of the first years here are females."

HH2: "To me it's just beliefs. They no longer exist. The reason being I have seen women; like this stereotype where it says women do not do Engineering because they do not do well in maths and science, I don't believe that coz I've seen women doing very well in mathematics and science. And then the thing that women cannot succeed in Engineering, also I don't believe in that coz I believe that it's all… you know what you want. Women they know like ok, someone said uhh success is a mindset. So your mindset, I mean women their mindset I think that they can do whatever they want as long as they set their minds to that."

7.3 Instructional Needs of Female Engineering Students

Relative to the results of previous studies (Jawitz and Case, 1998; Jawitz, Case and Tshabalala, 2000; Martineau, 1997; Royer, 1995) which have highlighted low numbers of female students studying Engineering, Kaufman (2003) and the author's analyses indicate that many of the female Engineering students taking Engineering graphics have experienced difficulties with the course content, and use a variety of strategies to get over their problems. Those female students who have not taken technical drawing at school level, and female students who do not network with other Engineering students are likely to be those at a disadvantage.

Kaufman (2003) and the author's analyses also indicate that social factors such as stereotype threat lower the likelihood that female students will attempt to enter Engineering as a field of study. In addition, the author has found that personal factors such as low self-efficacy of female students relative to the tasks they are required to do in their Engineering courses militate against their successful adaptation to university. Poorly developed three dimensional spatial perception ability at time of university entry presents one such barrier to successful first year study.

In relation to the two studies (Kaufman, 2000; 2003; Delacour, 2005) regarding students' Engineering performance and three dimensional spatial perception, the author has found out that that three dimensional spatial perception continues to be a major influence on the academic performance of all first year Engineering students. This in turn still negatively influences the academic performance of female Engineering students.

Most importantly, there has emerged two major findings in this study; that there are clear indications of emotionally related barriers to learning, relating to low careeer self efficacy and stereotype threat. These findings bring one to the realisation that female Engineering students should be identified as a group which is at risk for the reasons that many females had no technical drawing courses at school; negative career stereotyping as well as low career self-efficacy as indicated in the author's interviews and in Kaufman's study (Kaufman, 2000; 2003). It is also clear that females do need a lot of support in order to excel in the course, hence the usefulness of the instructional material developed by Van der Merwe and Potter (2000) designed specifically to aid students who are struggling with the course. Females also need to be encouraged to study cooperatively as individuals and as a group, so as to provide specific help, solidarity as well as emotional support as a female Engineering student group.

The pervious studies carried out at the University of the Witwatersrand (Potter & Van der Merwe 1982; 1983; 1992; 1995; Van der Merwe & Potter, 2000) have shown that all the elements for appropriate academic support for female Engineering students are actually

there and could be mobilised through the Dean of students. The results yielded in this study provide further evidence that female students need support, as it is clear that the majority of them have three dimensional spatial perceptual difficulties as well as emotional factors which act as barriers to successful first year of study.

7.4 Conclusion

From the results obtained in the study, one can deduce that males outperform female Engineering students academically for the reason that they have better developed spatial abilities than females; and that students in the mainstream Engineering graphics outperform students having special tuition in the subject, also for the reason that they have better developed three dimensional spatial perception. It is evident not only that male students outnumber female students numerically, but that those female students studying first year Engineering are not so confident about their abilities, as shown in the low self-efficacy they possess.

There is thus a self-perpetuating cycle of stereotyping which commences with female students not choosing technical subjects at school. Given poorly developed three dimensional spatial perception at time of university intake, the evidence from this study would suggest that female students lack the skills necessary to passing university courses such as Engineering graphics. This study would thus suggest that the process of stereotyping continues at university, where female students find themselves among the minority of students underprepared for the courses necessary to succeeding in their first year studies, and have low self-efficacy relative to Engineering as a male-dominated career.

Chapter 8: Conclusions, Limitations and Needs for Further Research

This study has attempted to answer two broad evaluative questions:

- A. How do female Engineering students cope with their studies?
- B. Is three dimensional spatial perception an influence on how female Engineering students cope with their studies?

The conclusions of the study with respect to these two questions are as follows:

8.1 How do female Engineering students cope with their studies?

It was found that female Engineering students used three main methods of study both for Engineering graphics and for other subjects. There were

- reading alone
- studying in groups
- Using both methods of study.

However, it was evident from some of the students that when approaching other subjects, it was important to understand the concepts very well, whereas Engineering graphics needed a lot of practice with three dimensional drawings. It was also discovered that males and females did not differ that much in the methods of study used in coping with demands of the course. It was also discovered that female Engineering students performed less well than male students in their studies and that they felt they had to work especially hard as right from school level they were underprepared for the type of work they have to do at university.

8.2 Is three dimensional spatial perception an influence on how female Engineering students cope with their studies?

From the quantitative analysis, it was found that males outperformed females in Engineering graphics precisely because they possessed well developed three dimensional spatial perception. In addition, the author discovered that students in the mainstream Engineering graphics course outperformed students having special tuition in the subject, also for the reason that they had better developed three dimensional spatial perception. The qualitative analyses from this study indicated that many of the female Engineering students taking Engineering graphics had experienced difficulties with the course content, and used a variety of strategies to get over their problems. Those female students who had not taken technical drawing at school level and female students who did not network with other Engineering students were found to be likely to be at a disadvantage. The qualitative analyses from this study also indicated that social factors such as stereotype threat lowered the likelihood of female students attempting to enter Engineering as a field of study. Furthermore, personal factors such as low self-efficacy of female students relative to the tasks they were required to do in their Engineering courses militated against their successful adaptation to university.

8.3 Conceptual Limitations

Defining the concept of thematic analysis or even thematic content analysis has been problematic as many authors have shown that it is not easy to define the concept; there seems to exist many definitions of the concept (Attrittude-Stirling, 2001; Boyatzis, 1998). Spatial Ability was also found to be even more problematic as even the authors themselves did not know whether to call it spatial ability, perception, three dimensional visualisation or visuo-spatial abilities (Mc. Arthur & Wellner, 1996; Rafi, Samsudin & Ismail, 2006).

8.4 Methodological Limitations

Some of the participants did not take the F and the H tests of spatial ability seriously because the tests were not for marks. Others expressed that it was because they really did not understand what was going on and therefore they just wanted to get the tests over and done with. This could have affected the validity and the reliability of the results in the report.

The researcher was under time constraints as she had to complete her coursework and her masters dissertation at the same time. The sample was also a bit large (36) and it was content analysed manually, which was extremely tedious. The participants themselves also had lectures to attend, therefore it was not easy to get them to come for interviews as they also had a tight schedule.

When asked about certain issues such as stereotypes affecting women's performance in Engineering, most male participants seemed to give answers that they thought the researcher wanted to hear because she was a female too. For future research, it is recommended that interviews be conducted by both male and female researchers so as to see if the same responses will be given, thus resulting in true and more authentic results.

External Validity refers to the generalisability of the findings beyond the place where research took place (Murphy and Davidshover, 2001). The external validity for the findings of this report cannot be generalised to other samples because the teaching methods and the experiences students have had in Engineering graphics are unique to the University of the Witwatersrand.

8.5 Recommendations for further research

Voluntary Saturday/Extra Classes

Voluntary Saturday classes should be offered for females and all students who have poorly developed spatial abilities to scaffold these students' spatial abilities as this has been shown to improve students' spatial abilities (Agogino, 1995).

Enhancement of Self-Concept and Self-Efficacy

It is also recommended that programmes that facilitate female students in developing their self-concept be implemented, as it was discovered in the interviews that most female students do not get support from their families and communities to embark in Engineering. This would also be more effective if the community at large is also educated on such issues so that they become more supportive of their daughters.

Lack of same-sex and same-race role-models for females deter females from excelling in Engineering graphics, and vice versa. More incentives should be offered by the government to attract as many females as possible into the field of Engineering. These incentives may be in the form of bursaries and high salaries for females in the field of Engineering.

Schools should offer Career Guidance to learners

From the interviews, it was apparent that the majority of schools did not offer career guidance to their learners; hence they choose careers without thorough knowledge of what that career entails. Most of them end badly because they entered the field for the wrong reasons and they were not adequately prepared for the particular career.

In addition, schools must offer educational tours to Engineering firms so that learners are well informed about what Engineering entails before venturing into the field. Schools and universities should invite female role models for motivational talks.

Most participants showed that at school, many girls did not take courses like technical drawing because it is seen as a boys' course. In fact teachers encouraged girls not to take such courses because they are not for girls. It is highly important that technical drawing be made available in all schools and be offered to all learners, regardless of their sex.

Furthermore, many participants expressed concern with mathematics and physics. It is imperative that schools and universities reach out to the students more in order to be able to help them excel in these courses. Perhaps the next research should not be on Engineering graphics but on physics, mathematics and chemistry, as these are the courses that students raised concern about.

Future research should investigate the impact of Ethnicity, Socioeconomic status and Age

The backward stepwise regression results showed that only 25% of the variance in academic performance was explained by the predictor variables namely gender, group and three dimensional spatial perception for the mainstream class and only 18% for the special programme class. This meant that other factors such as ethnicity, socioeconomic status and age could have explained the other variance. It is therefore recommended that these variables be included in the questionnaires for future research. Most importantly, as self-efficacy and stereotype threat emerged as two of the most important themes in explaining the differences in males' and academic performance in Engineering graphics, it is suggested that more research be done in these two fields.

8.9 Conclusion

Major findings in this study have indicated that many female students are experiencing difficulties in engineering graphics due to:

1. Low self-efficacy
2. Stereotype threat
3. lack of three dimensional perception

Apart form the recommendations already mentioned above, the main suggestion that can even be mobilized at the university has been that there should be support offered by the university to students more especially because material appropriate for this task is already available (Van der Merwer & Potter, 2000). This way, academic performance will be improved; stereotype beliefs of females not skilled enough to do well in engineering will be done away with. Females' self-efficacy will also be boosted dramatically, resulting in a South Africa that has confident, capable and competent female engineers.

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Appendix One: A Matrix of Theme Agreements and Disagreements between males and females

Research Question One - How do female Engineering students cope with their studies?

Sub Question a: What strategies are used by female Engineering students in making the transition from school to university? In order to answer sub question a., participants were asked two questions namely how they studied for engineering graphics and how women could be helped to adapt to university life.

Table 6. 1 Study Methods for Engineering Graphics: Reading Theme

Gender	Males	Examples		Females	Examples
Theme	Reading			Reading	
	BB3	Um you just practice; you just have to, like do all the tuts		B3	I just do most of the stuff during the tut, I do by myself.
	CC3	I work best when I'm on my own,		C3	I study by myself, I go through past papers and I do exercises ya
	DD3	I work best by myself, everything before I go to the lecture.		F4	I'd rather work on my own
	FF3	I study alone.		I5	Do the practice exercises.
	II3	I study when I've got homework and an assignment ya		J5	I do it alone most of the time
	JJ3	Just do the exercises again. Emm, what you've done in the past; you go through…		N4	I practice,

		past papers			
	NN3	It doesn't happen often but I just take a few tutorials and go over them.		R4	I study alone
	QQ3	I study by myself.		G5	I use the library and the books there.
	RR4	I study alone.		H3	Before the day I just do like a few drawings.
	EE6	I study alone. I just do exercises.		P4	I study alone.
	GG6	I practice at home.		-	
	KK5	I study by myself		-	
	LL3	I just do the tuts.		-	
	MM4	You get most of your experience from the tutorial lessons		-	
Totals	14 males			10 females	

Table 6. 2 Study Methods for Engineering Graphics: Group Theme

Gender	Males	Examples	Females	Examples
Theme	Group		Group	
	DD3	I study with my friends.	O4	Well I usually ask one of my friends who've done TD at school.
	HH3	when I'm studying I make it a point that we study in groups	M4	I study with my friends
			Q2	I study with friends.
Totals	2 Males		3 Females	

Table 6. 3 Study Methods used by engineering students for Engineering Graphics module: both Reading alone and studying in a group

Gender	Males	Examples	Females	Examples
Theme	Both			
	AA3	With graphics I mostly study alone and then I sometimes acquire help from others.	K4	I study on my own and sometimes with my friends.
	HH3	I work by myself, if I don't understand I have a friend who understands the course and then I normally…I do ask him.	D4	…it's nice to study with friends coz we kind of compare like in class.
	OO3	Practice a bit myself and then go and talk to some people and we like let me see yours.	L4	I study by myself and then go to my friends to compare…
Totals	3 Males		3 Females	

Table 6.4 How can Women be helped to adapt from school to university?

Gender	Males	Examples	Females	Examples
Theme	EE4	Slower maths classes	P4	Slower maths lectures
	KK4	Teach women independence at school	D4	Confidence
	LL4	Responsibility		
	MM5	Break down stereotypes		
	AA3	Hard Work	F4	Hard work
	BB3	Change of mindset	K5	Change of mindset
	CC3	Responsibility		
	DD3	Hard work		
	FF3	Oweek	L5	Oweek
	HH3	Change of mindset		
	II3	Improved lecturing		
	JJ3	Improved lecturing		
	OO3	Motivation		
	PP3	Extra tutorials	H4	More lectures
			A4	Special Programme
			G 6	Study groups
			M5, O4	TD at schools
			E 4	Individual tutors
			I6	Counselling
			J6, N3	Prep from school
Totals	14 Males		14 Females	

Sub Question b: Are similar strategies effective in studying all first year Engineering subjects, or are different strategies necessary in studying Engineering Graphics?

This question was addressed by looking into study methods used by the participants when studying for other subjects.

Table 6.5 Study Methods used by engineering students when studying for other subjects: Reading alone Theme

Gender	Males	Examples	Females	Examples
Theme	Reading			
	AA3	With physics and maths, err normally the best way to work through is by working through past exam papers and tutorials	D4	I do the tuts. Obviously I read through the notes and then I do the tuts.
	BB3	Just read and read and read and practice.	L4 R4	I just practice. I learn the theories, practice my tutorial questions. Uum for mechanics and maths and all of them I practice.
	CC3	With maths you basically go through examples that you did in class	I5	Ok, I take a text book, and make down notes in my own handwriting. And then I read my notes, and I read the lecturer's handouts or maybe whatever I took out of class
	II3	For other subjects I study a lot now. Like maybe in physics; physics takes maybe two hours of my time everyday, and maths as well.	K4	Uum, I usually study alone at first. For example Maths, I make sure that what I did today, I make sure I review and try to understand.
	JJ3	I study alone, rewrite the notes, talk to yourself, read the notes…	A3	Um, definitely alone for everything.
	NN3	I think working on	M4	I look at the past

		my own and doing problems.		papers…ya just practice and see if you can be able to do it.
	OO3	For other subjects I mainly study alone	B3 O4	I work best by myself. I prefer to study by myself.
	PP3	I cross night; the day before the test.		
	QQ3	I usually go to the library and study. I just study to understand the concepts	F4 J5	I look at the text book, I read whatever they've given us and I look at the examples that we've done and then use that. Ya I use the same method for all coz like maths I do something by myself and then I check the back of the book,
	RR4	I study alone	E3	I just sit and then I study
Totals	14 Males		12 Females	

Table 6. 6 Study Methods For Other Subjects: Group Theme

Gender	Males	Examples	Females	Examples
Theme	Group			
	DD3	I study with my friends.	C3	Uum, maths I normally study with friends,
	HH3	…when I'm studying I make it a point that we study in groups,	H3	If I find that I'm struggling then I do it with a group.
Totals	2 Males		2 Females	

Table 6. 7 Study Methods used by engineering students for Other Subjects apart from Engineering graphics: Both reading alone and studying in a group theme

Gender	Males	Examples	Females	Examples
Theme	Both			
	FF3	Like for physics, I usually do it with my friends because eish! It's giving me a hard time. But for some of them I still study alone.	G5	I study well by myself, but sometimes I ask my friends.
			K4	I usually study alone at first… And every Sunday there's three of us who live at res, we meet together if there's any problems within any subject.
Totals	1 Male		2 Females	

Appendix Two: Matrix of Agreements for suggested ways of improving academic performance in engineering graphics

Table 6.8 Strategies to Improve Women's Performance in Engineering Graphics

Gender	Males Group	Examples	Females Group	Examples
Theme				
Responsibility	CC3 SP QQ3 M LL4 M	People should just take responsibility for their studies. The thing lies with individuals, with us you know? You are the one who has problems, so like people who are doing engineering, most of them are lazy. You just have to be prepared to go through the work…		
Mindset	BB3 SP GG6 SP	I think it' just a mindset They should get rid of the idea that they have never done drawing at school	K5 SP R4 SP	I actually like the special programme coz at first I didn't wanna go into it , but then it was like no, I'm failing I need help. So first of all we have to accept help, second of all this programme should be enforced. I don't know if anyone can help except for that person. I think it's from the person's mind to say I want to do this and I will do it
Hard Work	AA3 SP DD3 SP RR4 M	I think that basically it's practice. There is no way you can do anything without practice. They can be helped by not doing graphics only; they should also draw pictures that are not specifically for graphics With graphics people need to practice, because people take this course for	F4 M	Umm, through work. Because like in engineering, most people are just laid back they don't really work."

		granted.		
O' week	FF3 SP	During the orientation week, if they could give them more advice on the courses they do	L5 SP	I like the idea of orientation week, you get introduced to things
Gender	Males Group	Examples	Females	Examples
Theme				
More lectures and tutorials	HH4 SP PP4 M	If they can have extra classes, yes and then enough time also to ask questions I don't know maybe two tutorial sessions a week; something like that.	Q4 SP H4 M	I think if we can have extra tutors, and even extra classes I think we should get more time in class
Improved Lecturing	II3 SP JJ3 M	They must do it (lecturing) in detail so that people can understand coz we are not the same. There's no point in giving us a tutorial for three hours learning how to do sth and the trying to complete the exercise for marks, coz by the time you've learnt how to do it you've already wasted half the time.		
Motivation	OO3 M	Maybe motivation, I don't know people seem to be bored at some stage.		
Slower Maths Lectures	EE4 SP	Well I thought like in Maths, like the lecturers could have gone like a little bit slow coz… I… they have like a time frame like they have to do some target. They rush through everything…		
Teach Women Confidence from School	KK4 M	I think the main thing from school is just (coughs), you need to be all independent. What I mean by that is uum, they (at school) need to give you more work		
Break Down	MM5 M	I think that there is…		

Stereotypes		looking at the questionnaire, there are a lot of perceptions of women in Engineering and I think some of those need to be broken down for women to really succeed in Engineering		
Extended Curriculum			B4 M	If the maths would be spread over two years, it makes it a lot easier because it is a difficult subject.
Individual Tutors			E4 M	I think individual tutors can help… you just get to…like somebody who you ask and then the person is going to be patient and all that.
Counselling			I6 M	First of all they should be sat; you should sit them down and ask them, are you really sure this is what you want to do
Preparation from School			J6 SP N3 SP	Ya the best thing to do is to go to the high schools like when they are doing grade 11 and grade 12, and then people should go there like social workers. Well I've noticed that at school uum, you are taught how to pass matric, but when you get here it's, it's a whole different, you know, universe because it's another way of doing things.
Schools should offer TD			O4 SP M5 SP	I think first of all a lot of all girls' schools in Durban don't offer TD, I think they should offer that definitely! I think first of all, like they must first teach like, er, teach them some of the stuff while they are still at school in

				matric or during the holidays, I mean the December holidays
Special Programme			A4 M	The special programme is definitely really good
			D4 M	If they get taught that they really are at the same level as men and not as the weaker man, ok not as the slower people. They can push as much as uum, they really can go forward.
Study Groups			G6 M	By study groups
Remove Gender Classification			P4 SP	The thing is the real reason that we are not doing well is we come here knowing that this is for men and not for women, so I can't do it. If you tell your mind that you can do this, then you just gonna do it

Table 6.9 Improvement of Academic Performance: Mainstream Group

Gender	Males	Examples	Females	Examples
Theme				
Responsibility	QQ3 LL4	The thing lies with individuals, with us you know? You are the one who has problems, so like people who are doing engineering, most of them are lazy. You just have to be prepared to go through the work…		
Hard Work	RR4	They can be helped by not doing graphics only; they should also draw pictures that are not specifically for graphics	F4	Umm, through work. Because like in engineering, most people are just laid back they don't really work."
More Lectures and Tutorials	PP4	I don't know maybe two tutorial sessions a week; something like that.	H4	I think we should get more time in class
Improved Lecturing	JJ3	There's no point in giving us a tutorial for three hours learning how to do sth and the trying to complete the exercise for marks, coz by the time you've learnt how to do it you've already wasted half the time.		
Motivation	OO3	Maybe motivation, I don't know people seem to be bored at some stage.		
Teach women confidence from school	KK4	I think the main thing from school is just (coughs), you need to be all independent. What I mean by that is uum, they (at school) need to give you more work		
Break down stereotypes	MM5	I think that there is… looking at the questionnaire, there are a lot of		

		perceptions of women in Engineering and I think some of those need to be broken down for women to really succeed in Engineering		
Extended Curriculum			B4	If the maths would be spread over two years, it makes it a lot easier because it is a difficult subject.
Individual Tutors			E4	I think individual tutors can help… you just get to…like somebody who you ask and then the person is going to be patient and all that.
Counselling			I6	First of all they should be sat; you should sit them down and ask them, are you really sure this is what you want to do
Special Programme			A4	The special programme is definitely really good
Confidence			D4	If they get taught that they really are at the same level as men and not as the weaker man, ok not as the slower people. They can push as much as uum, they really can go forward.
Study Groups			G6	By study groups

Table 6.10 Improvement of Academic Performance: Special Programme Group

Gender	Males	Examples	Females	Examples
Theme				
Responsibility	CC3	People should just take responsibility for their studies.		
Mindset	BB3 SP GG6 SP	I think it' just a mindset They should get rid of the idea that they have never done drawing at school	K5 R4	I actually like the special programme coz at first I didn't wanna go into it , but then it was like no, I'm failing I need help. So first of all we have to accept help, second of all this programme should be enforced. I don't know if anyone can help except for that person. I think it's from the person's mind to say I want to do this and I will do it
Hard Work	AA3 DD3	I think that basically it's practice. There is no way you can do anything without practice. They can be helped by not doing graphics only; they should also draw pictures that are not specifically for graphics		
O' week	FF3	During the orientation week, if they could give them more advice on the courses they do	L5	I like the idea of orientation week, you get introduced to things
More Lectures and Tutorials	HH4	If they can have extra classes, yes and then enough time also to ask questions	Q4	I think if we can have extra tutors, and even extra classes
Improved Lecturing	II3	They must do it (lecturing) in detail so that people can understand coz we are not the same.		
Slower Maths Lectures	EE4	Well I thought like in Maths, like the lecturers could have		

		gone like a little bit slow coz… I… they have like a time frame like they have to do some target. They rush through everything…		
Preparation from School			J6 N3	Ya the best thing to do is to go to the high schools like when they are doing grade 11 and grade 12, and then people should go there like social workers. Well I've noticed that at school uum, you are taught how to pass matric, but when you get here it's, it's a whole different, you know, universe because it's another way of doing things.
Schools should offer TD			O4 M5	I think first of all a lot of all girls' schools in Durban don't offer TD, I think they should offer that definitely! I think first of all, like they must first teach like, er, teach them some of the stuff while they are still at school in matric or during the holidays, I mean the December holidays
Remove Gender Classification			P4	The thing is the real reason that we are not doing well is we come here knowing that this is for men and not for women, so I can't do it. If you tell your mind that you can do this, then you just gonna do it

Appendix Three: Qualitative Data Questionnaire

Demographic Information

Please answer the following questions as carefully and as accurately as you possibly can. All the information will remain strictly confidential.

Please cross one box only:

Gender: Male ☐ Female ☐

Age: _____ (in years)

Student Number ☐

Group: Special ☐ Mainstream ☐

Background Information

Where did you attend school; a private or public school?

Do you think that the school one attended could have an effect on their performance in Engineering Graphics?

At your school, did you have career guidance regarding technical courses like drawing, design and woodwork?

Did you have Aptitude Tests? If not, do you think if you had you would have been able to do better in the F and H aptitude tests?

What are your mother's and father's occupations? Have your parents influenced your career choice?

Who do you think influenced your career choice?

Stereotypes about Engineering

What is your opinion about stereotypes held about women who study Engineering? For example

Engineering is for men only

Engineering is masculine
Women who study Engineering have masculine characteristics
Women do not study Engineering because they
do not perform well in mathematics and science

Women who study Engineering are not feminine

Women cannot succeed in Engineering

Experiences of the Engineering Graphics Course

What is your experience of the Engineering Graphics course since the beginning of the first quarter?

How did you find the first test in Engineering Graphics?

How do you find assignments and the course work as a whole?

How did you find the F and H tests of spatial ability?

What do you think contributed to the score you attained in the F and H tests (e.g time, prior experience in drawing lessons, etc)?

Do you think three dimensional spatial ability influences one's performance in their performance in Engineering.

What difficulties do you have regarding Engineering Graphics?

How do you go about studying for Engineering Graphics? (help from friends, tutors, peers, self help)

Do you think that similar strategies are effective in studying all first year Engineering subjects, or are different strategies necessary in studying Engineering Graphics?

What in your opinion, should be done to improve the performance of women who study Engineering and also to help them bridge the gap from school into university?

Thank you for participating in the study!