THE EFFECT OF SINGLE SEX SCHOOLING ON GIRLS' ACHIEVEMENT IN PHYSICAL SCIENCE

by

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submitted in part fulfillment of the requirements for the degree of

MASTER OF EDUCATION
(with specialization in Natural Science Teaching)

at the

UNIVERSITY OF SOUTH AFRICA

(FACULTY OF FURTHER TEACHER EDUCATION)

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JUNE 2005

SUMMARY

This study investigated whether girls achieve better results in Physical Science in single sex environments or in co-educational classes. Thirteen independent South African schools where children were of similar socio-economic background were considered.

Grade 12 Matriculation Physical Science examination results for 1999 to 2003 were analysed using Bonferroni (Dunn) t-Tests and Scheffe's Tests. Questionnaires were completed by a small number of students in order to compare their attitudes towards Physical Science and examined qualitatively.

There were significant differences found by the administration of the Bonferroni (Dunn) t-Tests and Scheffe's Tests in 2000, 2001 and 2002 to indicate that girls in single sex schools achieved better results in Science than the co-educational schools. However, in 1999 and 2003 there was no significant difference in the results achieved, and so there may be other factors that are more important predictors of achievement than whether the schools are mixed or single sex.

KEY TERMS

Single sex education, co-educational education, academic performance, science achievement, girls' academic achievement, Grade 12 female science students, performance in Grade 12 examinations, gender effects, quantitative statistical analysis of achievement, factors affecting performance, mixed classes

DECLARATION

I declare that “The Effect Of Single Sex Schooling On Girls’ Achievement In Physical Science” is my own work and that all sources that I have used or quoted have been indicated and acknowledged by means of complete references.

ACKNOWLEDGEMENTS

Thank you, Prof. Mashile, for your guidance and assistance.

I could not have completed this degree without the support of my husband, Nicholas Carter, and my children, Jonathan and Jessica. Thank you.

TABLE OF CONTENTS

Chapter 1 Introduction to the problem

1.1. Background to the research

This dissertation explores the impact of single sex secondary education on the achievement of girls in Physical Science. The first chapter outlines the background, research, research methodology and overall structure of the dissertation.

Much of the research into gender issues in education reveals that girls do not achieve as well as boys in Physical Science (Levin, Sabar & Libman 1991:315; Young & Fraser 1990:5; Becker 1989:162). Furthermore, it appears that girls do not enjoy the subject as much as boys, lack confidence in their ability in Science, and that fewer numbers of girls choose to study Physical Science at tertiary level than boys (Spielhofer, O'Donnell, Benton, Schagen & Schagen 2002:12, Elwood & Gipps 1999:39). This may, in part, be due to the traditional stereotypical belief that many students, parents and teachers have that Physical Science is a "boys' subject".

It might be possible to act positively to counteract this stereotyping in single sex schools. By educating girls in Science classes where only girls are present, and by presenting Science courses in a way that overtly dismisses the claim that Science is for boys, girls may be able to achieve better results in Science, and may develop a more positive attitude towards the subject. This could result in more girls pursuing scientific careers and studying Science courses at tertiary level.

Many studies have been conducted into gender effects on achievement, especially with regard to Mathematics and Physical Science, comparing how boys achieve compared to girls, comparing attitudes and career choices of boys and girls, and looking at school effects. Results of most of the studies of the effect of single sex versus co-educational schooling on achievement are of limited value, as it is difficult to compare single sex and co-educational schools because of the shortage of single sex government schools and co-educational independent schools. The children attending independent schools are traditionally from moneyed, advantaged backgrounds, and so comparing their achievements with children from government schools is difficult, because differences such as socio-economic background, parental education level and class size have a great effect on achievement. It is therefore not

possible to prove that the differences in achievement can be attributed to the fact that a school is single sex or co-educational. Most studies that have been done have been carried out over a wide range of schools, incorporating many different backgrounds, school types, etc. Even in those studies in which background variables have been accounted for, it is difficult to make a conclusive case for or against single sex schooling based on achievement of girls in these schools compared with their peers in co-educational schools.

In searching for literature specifically on the effects of single sex schooling on girls' achievement in Physical Science, recently published research is, on the whole, inconclusive and at times contradictory. This was also cited as a problem in research conducted by Thomas Spielhofer et al, where it is stated "The research literature (thus) failed to provide convincing evidence that single sex education has an impact on pupil performance" (Spielhofer et al 2002: iii).

In this dissertation, an attempt has been made to account for as many of these differences (including socioeconomic background of the students) as possible, and samples and subjects were carefully chosen in order to minimize as many of the extraneous variables as possible, by choosing schools that were very similar in most aspects, except for whether they were single sex or co-educational. This means that the sample size is relatively small, and that there are limitations to the generalization of the research. However, it may provide important evidence with regard to the effect of single sex schooling on girls' achievement in Physical Science that could provide the basis for further studies. It is hoped that any significant difference in achievement between girls in single sex and co-educational schools will be directly related to the schools type, and not reflect differences in student background, school size, and so on.

1.2. Research problem

The research problem investigated was whether girls achieve better results in Physical Science in single sex environments as compared with co-educational classes in mixed secondary schools. The schools considered were all independent schools, with eleven schools situated in Gauteng and two schools in Kwazulu Natal.

Because the research problem was limited only to the success of girls in Science with regard to the type of school (whether single sex or co-educational) and not with regard to socioeconomic status and class, the control of significant variables was extremely important.

1.2.1. Independent and Dependent Variables

The independent variable is the type of school that the girls attended. The schools are either single sex or co-educational. The dependent variable is the mark they achieved in Grade 12 for Physical Science. This mark was determined through the administration of the Independent Examinations Board Matriculation Examination, of which the students wrote one 2 hour Chemistry paper and one 2 hour Physics paper. A few of the students wrote the examination on the Standard Grade and have been considered separately to the students who wrote on the Higher Grade.

1.2.2. Control of other variables

The researcher has attempted to control a number of variables in order to ensure that the results reflect only the single sex effect of schooling, rather than the effects of socio-economic background, class size, and so on.

Variables that have been shown to have the greatest effect on school achievement are socio-economic background, cultural and family background, parent's education level and type of profession, class size and tradition of the school (Elwood & Gipps 1999:51; Spielhofer et al 2002:48,49). This has caused the most significant barrier to effectively comparing single sex and co-educational schools, since most single sex schools are private, and the students are from higher socioeconomic backgrounds, whereas most co-educational schools are state schools, where children are not from advantaged backgrounds. The background of the children therefore accounts for most of the differences in academic achievement.

Although some of the schools were bigger than others, the class sizes of all the samples chosen in this research were similar, and did not exceed 24 students per class. All the schools are independent schools, in affluent areas, with high school fees, and

many of the factors of socio-economic, cultural and family background are similar in the schools, and have, as much as was possible, been controlled. The Science teachers in these schools all have, at least, a degree and a teacher's diploma, and so teacher effects, while still operating to some extent, have been minimized. The students in Grade 12 in these schools are all 17 or 18 years of age. The students in these schools come from similar advantaged backgrounds, and have excellent facilities and resources at their disposal. All subjects used in this research study wrote the same examination, at the same time, with each examination being restricted to two hours for the Chemistry paper, and two hours for the Physics paper.

It was necessary to use independent schools in this study, because that is the sector in which there are more single sex schools. However, this meant that the number of co-educational schools used was severely restricted, as most established independent schools are single sex. Most of the co-educational independent schools are relatively new, and the numbers of girls taking Science within these schools was very low. Thus, variables related to establishment and traditions of the school could not adequately be controlled.

The ability of the girls could not be tested because of the *Ex Post Facto* nature of the research. The decision to use this approach is discussed in Chapter 3. Although the ability of the girls was not tested, all of these schools offer Science to girls as a choice subject, and not as a compulsory subject, and most of the students who have chosen to study Science tend to have a relatively high academic ability. Most of the students attending independent schools have parents who are entrepreneurs or professionals, and are from an advantaged section of the community. They have a relatively educated background and are mostly from families who place emphasis on education for their children. Also, many of these schools are full, and are in a position to choose their students. This selection process tends to favour academically stronger students.

1.3. Research Method

The research conducted in this dissertation was divided into three parts, the critical review and analysis of published literature relating to the topic, the analysis of Grade 12 examination results in a number of independent single sex and co-educational

secondary schools, and the analysis of questionnaires that were completed by some students in order to compare their attitudes towards Physical Science.

1.3.1. Critical Review and Analysis of Published Literature

A range of databases was searched in an attempt to discover literature relating to this topic. However, the literature on this topic is inconclusive and divided. The search was done by the UNISA library, and included searches of all the important databases. Internet searches were also done in order to try to find additional research. Much of the literature that was consulted has not been included in the list of references, as it did not relate directly to the question of single sex school effects on girls' achievement in Physical Science, but rather on other gender related issues.

1.3.2. Analysis of Examination Results

Statistical analysis was done on Grade 12 examination results achieved by female Science students obtained from a number of independent secondary schools in South Africa. The data was collected from a relatively small sample of schools, in an attempt to ensure that background variables such as class size, socioeconomic background of students, etc were as similar as possible across the range of schools. Unfortunately, because the Independent Examination Board would not release any of these results, it was necessary to approach each school individually to request the information.

The data was then analysed in order to determine whether single sex schooling has an effect on Science achievement. Bonferroni (Dunn) t-Tests and Scheffe's Tests were used to statistically analyse the difference between the girls' achievement in single sex schools compared with those in co-educational schools in each year from 1999 to 2003. This was done separately for the Higher Grade and Standard Grade students.

1.3.3. Analysis of Student Response to Questionnaires

Because of the small sample size, the lack of large co-educational independent schools that had been established for any length of time, and the relatively small number of girls seeming to take Science in the co-educational schools, it was deemed

necessary to request that a number of students complete a questionnaire in an attempt to find out why so few girls were choosing Science as a subject in so many of the co-educational schools. An established single sex (School A) and co-educational (School J) school were contacted, and asked to choose students with differing abilities to complete the questionnaire. These were completed and returned. A co-educational school that had been established very recently was also asked to complete a number of questionnaires, and although the Head of the school agreed to this, the Science teacher did not administer the questionnaires. This was unfortunate, because the more recently established schools tended to have very low numbers of girls taking Physical Science as a subject, and the results tended to be quite poor compared to the single sex schools, and also to the established co-educational school.

These questionnaires were analysed qualitatively, by comparing the girls' attitudes in single sex schools with regard to Science with those of the girls at co-educational schools.

1.4. Results and Interpretation of the Results

1.4.1. Critical Review and Analysis of Published Literature

The available published literature was reviewed, and conclusions were made concerning the results found in other studies completed in this field from the 1980s to the present day in countries around the world.

1.4.2. Analysis of Examination Results

The results of the girls writing the Matriculation Physical Science Examination from the thirteen schools from 1999 to 2003 were compared. This was done by determining the average results of the girls who wrote the examination each year, and considering also the number of girls who wrote in each school, and the number of "first class" passes that were achieved (where "first class" pass refers to marks above 70 %).

The results of the single sex schools were compared with the co-educational schools using Bonferroni (Dunn) t-Tests and Scheffe's Tests.

1.4.3. Analysis of Student Response to Questionnaires

The responses given by students during the administration of "Questionnaire B: for students" were studied in an attempt to understand some of the differences between the results achieved in single sex and co-educational schools. Because of the small sample size, it was not possible to do a statistical analysis of the responses. Rather, these responses have been considered in a qualitative way.

1.5. Significance of the study

In South Africa, black girls and women have been the greatest victims of disadvantage, abuse and lack of schooling. Single sex education for this portion of the population may hold the key to the upliftment of women in South Africa, in an atmosphere that is caring, nurturing and free of the oppression that they experience in their homes and in their communities. It is obviously an area requiring much research and consideration for the cultural norms and beliefs of the society, but it may be the best way of ensuring that girls are educated in a safe, secure and understanding environment.

Although this study is focusing on only a limited aspect of the success of girls in Science, using a small sample group of girls from advantaged socio-economic backgrounds, the results from this study may show that at least the academic achievement of girls in Science may be greater in a single sex environment. The implications of this are great, because there are very few single sex government schools in South Africa. Further research would need to be conducted to ascertain whether grouping children according to their gender within co-educational schools may have similar positive effects on the achievement of girls academically. This would be a more financially viable option for state schools than opening new single sex schools, although it does not address the problems of sexual harassment and violence against girls in co-educational schools. Developing countries, including South Africa, may find that single sex schooling holds the answer to some of the problems of girls' achievement and lack of confidence, as well as providing a safe environment for the girls physically and emotionally.

Most of the prior studies conducted around single sex versus co-educational schooling have been done in situations where significant variables have not been able to be controlled. In developing countries, girls tend to leave school very early to get married and the schooling of girls is poorly funded, and so studies performed in these countries are also difficult to conduct. It is difficult to assess the achievement of students under conditions where schools lack trained teachers, adequate facilities and resources, and where the students are often malnourished and from home environments that are not conducive to studying.

The fact that this study focuses on a small sample group, where the backgrounds of the children and the schools is similar, has produced results that provide specific evidence on the effect of single sex education on the achievement of girls in Physical Science, rather than this effect being obscured by factors such as socio-economic background, etc. Whereas much of the research suggests that in order for the data to be reliable and generalisable a larger sample group needs to be taken, it is the intention in this study to take a smaller sample, where as many background variables as possible are similar between the schools that have been selected. All the schools chosen have similar school and pupil effects, in that the schools are all independent, located in similar wealthy areas, where the children attending the schools are on the whole from similar privileged socioeconomic backgrounds, where the school fees limit the intake of the students to a particular social class, where the ethnic make-up of the schools is similar, and the schools represent similar religious and cultural backgrounds. Most of the larger studies conducted used co-educational and single sex schools with very different backgrounds, comparing independent, government, Catholic schools in one study.

This study has also been limited to considering only the effect of single sex education on girls' achievement, and then, only within the area of Physical Science. It is not concerned with the achievement of boys in single sex environments compared with mixed schools, and does not seek to compare girls' and boys' achievement. Very few studies have focused on girls' achievement within similar schools, without comparing them with boys' achievement, and many of the studies have compared achievement of girls from schools that are very different. Very few studies have focused on the

effects of single sex schooling on girls only in terms of their achievement in Physical Science.

Science is an area which few women choose to pursue as a career, and understanding how to encourage and support girls to achieve in Science, and to enjoy Science as a subject, may help in the design of schools and curricula in such a way that girls are encouraged to pursue scientific careers. It seems from research done in the United Kingdom, that girls begin to fall behind in Science compared with boys as early as age 11, and that this seems to be a world-wide trend (Arnot, Gray, James, Rudduck & Duveen 1998:21). This dissertation may provide evidence that girls may be more encouraged to choose Science as a subject if taught in a single sex environment, and may achieve better results in Science in this environment.

1.6. Summary of Chapters

Chapter 2 of this dissertation summarizes and assesses the significance of existing research on the topic of the effect of single sex schooling on girls' achievement, particularly in the area of Physical Science.

In Chapter 3, the research design, sampling techniques and procedures used in carrying out the research is outlined.

The findings resulting from the analysis of the data are summarized in Chapter 4.

Chapter 5 includes conclusions, recommendations for further study, suggests limitations of the research conducted in this dissertation, and examines the significance of the results obtained.

The appendices include copies of the letters and questionnaires sent to the schools and to the students, as well as details of the data obtained and the analyses performed.

Chapter 2 Review of the literature

2.1. Introduction

The debate about whether single sex schools are better than co-educational schools and vice versa is one that has been ongoing for many years, and seems likely to continue. Most of the public appears to be in favour of co-educational schooling, while a number of professional educationalists have returned to the belief that single sex education is more beneficial (Shaw 1995: 129). There has been recent interest in the possible advantages of single sex grouping within mixed schools in order to gain the benefits inherent in both types of groupings (Stables 1996: 164).

Traditionally, in countries like the United Kingdom, single sex schools were the norm, because it was deemed natural for girls and boys to be educated separately, because of the different roles they would fill in later life. Girls were prepared for their futures as wives and mothers in the home, while boys were prepared for their role as husbands and professionals in the world of work.

Research done during the 1960s and 1970s by Dale (1969) proposed that there were more benefits for boys and girls in being educated in mixed settings, which was viewed as a more progressive form of secondary schooling. The drive behind this was the pursuit of equal opportunities for all. Dale advocated co-education as favouring better social development, and boys' academic achievement, and suggested that girls' progress was not harmed by co-educational schooling. Many single sex schools in the United Kingdom, America and Australia have subsequently transformed into co-educational schools.

However, organisations such as the American Association of University Women have been critically looking into the effects of co-educational schooling on girls' achievements, and have suggested that boys' and girls' schooling needs to be rethought, particularly in America, where most schools are co-educational (Elwood & Gipps 1999:7).

Feminists in the United Kingdom in the late 1970s and early 1980s advocated that single sex schools were places where girls achieved better results. In 1976, according to Elwood & Gipps (1999:7), Shaw proposed that girls' academic achievement was closely linked to school type, where most of the high achievers attended single sex schools . Other researchers found that girls were more likely to take Mathematics and Science in girls-only schools, even though these schools were generally less equipped in the classrooms and laboratories. This generated an apparent contradiction, where girls were thought to do better in single–sex schools, while boys do better in co-educational schools (Elwood & Gipps 1999:7).

Research was conducted by the Equal Opportunities Commission (EOC) in the United Kingdom in 1983, which found evidence for and against single sex schooling, especially those claims that girls do better academically in single sex schools, feel freer to choose a wider range of subjects and therefore follow less sex-stereotyped careers (Elwood & Gipps 1999:7). However, this research, conducted by Bone, concluded that children's performance was far more influenced by the type and style of the school, than whether it was single sex or co-educational (Elwood & Gipps 1999:8).

Education in Africa is marked by low levels of access by girls, according to Morrell (2000:227). There has been a sharp rise in sexual violence in educational institutions, which, apart from the problem in terms of safety of girls in these schools, has implications for the women's ability to complete their studies (Morrell 2000: 228). Youth clubs and cults, as well as male teachers are responsible for sexual harassment and violence against girls in schools. The girls are in physical danger at school, and many do not complete their schooling because they fall pregnant.

Schools in South Africa were modeled on the British schools in the mid to late nineteenth century. They were also, from inception, racially segregated. In the beginning of the twentieth century, schooling became compulsory for white children. The white boys and girls attended single sex schools, Afrikaans speaking children attended co-educational schools, while few Africans attended school. Most African children received little or no schooling, until the Bantu Education Act was passed in 1953, providing compulsory schooling for non-white children that was coeducational,

and designed to perpetuate Apartheid. In 1996, the South African Schools Act introduced an integrated education system aimed at redressing the imbalance in the education system. One of the issues that were also addressed was that of gender inequality, with the following recommendation advocated by the Gender Equity Task Team (GETT):

> In recommending support for single sex schools for girls, this report is advocating that such schools be supported where there is an active policy for developing excellence in girls' education, provision for security for girls from harassment and violence and where such schooling provides affirmative programmes designed to equip girls with a high level of consciousness about women's and girl's human rights (Morrell 2000:222).

So far, no single sex schools for black working class girls have been established, although a limited number of black middle class girls have gained access to existing single sex, formerly white, schools. Most of the single sex schools remain in the private sector, where access is restricted to the upper socio-economic class, while most of the government schools are co-educational. Most of the newly established independent schools are co-educational rather than single sex, reflecting the trends in the United Kingdom, United States of America and Australia.

2.2. The Arguments For and Against Single Sex Schooling

The arguments against single sex schooling include the belief that single sex education is a barrier to successful teenage cross-sex socialization (Lee & Lockhead 1989:4). In fact, it is feared that single sex schooling will restrict girls, give them "a holy fear of sex", make them unable to have a relationship with the opposite sex and that it will encourage an unrealistic view of society (Kruse 1996: 174).

Other studies have shown that girls in single sex schools may hold less stereotypic attitudes than those in co-educational schools, including their views of women's roles in society, the appropriateness of women entering typically male professions and

feminism. They appear to display less fear of success and be more open to entering leadership roles (Lee & Lockhead 1989:8). This may be partly due to the role models available in these schools, where the majority of the teaching staff is usually female. Much of the literature also suggests that single sex environments are academically advantageous for girls because of the improvement in their confidence, in their increased involvement and participation in class, the lack of distraction by boys and in the possibility that they receive more attention from their teachers when there are no boys present (Spielhofer et al 2002:iii, 12). However, there is little published evidence that shows that these benefits result in improved performance shown in academic results (Spielhofer et al 2002:iii). It does seem that when boys and girls are mixed, there is a tendency for each group to assert their sexual identity and define themselves by means of behaviour, and indeed by subject choice, choosing subjects that are traditionally seen to be masculine or feminine (Elwood & Gipps 1999:38).

Studies over the past quarter of a century have documented gender bias against girls in co-educational classrooms, and there is a recent concern that gender equity solutions may have reached girls of different ethnic groupings unequally (Datnow & Hubbard 2002:3). It is now generally accepted that gender bias does not exist as an isolated problem, but is part of a bigger problem involving race, class and sexuality, and affects both boys and girls (Datnow & Hubbard 2002:3).

There is some evidence that girls benefit from and enjoy being in class with other girls (Streitmatter 1999:56). Teachers exposed to both single sex and co-educational classes, according to Streitmatter (1999:79), believed that girls did better academically in single sex classes – indeed that a very different, positive climate was established within the classroom, and that the girls feel freer to be themselves in this environment. The girls seem to find fewer distractions to learning, they have all of the teacher's attention and they did not need to make a space in a different culture, because the culture within the classroom was theirs, "a place they understood and did not need to fear" (Streitmatter 1999:87). The perceptions of girls seem to be that their learning was improved without boys, and that they were more focused, more at ease, and experienced more camaraderie in the classroom. They found that they did not have to battle to get attention from the teacher and control of the classroom. The girls

felt that they could ask and answer questions without the risk of “feeling stupid”, and felt more empowered because of this (Streitmatter 1999:105).

It does seem that single sex schools and classes promoted girls’ confidence and self-esteem, and allowed them to more accurately estimate their own abilities (Elwood & Gipps 1999:52). In studies conducted by Elwood and Gipps (1999:53) students who attended single sex schools believed that they had been academically advantaged, whereas attendance at co-educational schools was viewed to have been socially beneficial. Students in co-educational schools tended to have a more positive view of the schools’ impact on their social and personal development, and have less traditional views about work and family roles. Girls who had attended single sex schools felt that they would have been distracted by the presence of boys, and value having been stretched academically, but mention spitefulness and competitiveness as negative aspects of this type of schooling. Girls from co-educational schools rejected the idea that boys dominated the lessons (Elwood & Gipps 1999:53). Despite this, subject choice is more polarized at co-educational schools, and girls in single sex schools tend to take Mathematics and Science more than those at mixed schools (Elwood & Gipps 1999:53). There seems to be a positive effect on the confidence and academic performance of girls in single sex classes (Elwood & Gipps 1999:54).

It appears from the literature, that boys contribute prominently, both physically and verbally, during interactions within the classroom, and that the boys have these contributions evaluated, both positively and negatively, by teachers and peers, more than the girls’ contributions (Arnot et al 1998:26). Patterns of classroom interaction have implications, not only for the pupils’ performance, but also in the development of their attitudes and strategies (Arnot et al 1998:27). Girls request help more than boys, and are generally more attentive in class and more willing to learn (Arnot et al 1998:26, 28). Girls tend to value the contexts in which tasks are set, and take account of them in their responses in the task. Boys and girls prefer different styles of response to assessment items that reflect their reading and writing preferences. These differences may be reflected in the differences in performance in certain subjects (Arnot et al 1998:40). Thus, teaching boys and girls seems to require very different environments, emphasis, contexts and techniques of teaching and assessment.

There is a perception among some educators and people in other spheres of the community that girls in single sex schools perform best across all phases of education. However, within single sex schools, performance varies according to the type of school, patterns of performance within the school, and with differing intakes (Elwood & Gipps 1999:2). There are, therefore, factors at work other than merely whether schools are single sex or co-educational. Shmurak (1998:173) suggests that she found such few differences between the two types of schools, that she reached the conclusion that both types are very effective learning environments, and that girls tend to choose the school that "fits them best".

Elwood and Gipps (1999:3) suggest that the performance patterns of boys and girls are changing, and that the old stereotypes no longer apply. Traditionally, Science, Mathematics, Technology, Information Technology and Physical Education are regarded by students as "masculine", and preferred by boys, while English, Humanities, Music and similar subjects are regarded as "feminine" subjects, and are preferred by girls. It does seem that students' subject preferences and choices are becoming less sex-stereotyped, with girls more readily choosing to try the "masculine" subjects (Arnot et al 1998:31). It is also suggested that the relationship between gender and achievement is not a simple one, and that this relationship varies depending on social class and ethnicity of the children (Elwood & Gipps 1999:17).

In some developing countries, research indicates that girls are discouraged from attending school (where most of the government schools are co-educational) because of the threat of physical abuse, rape and pregnancy. These threats are minimized in schools where most of the staff and all of the students are female (Lee & Lockhead 1989:37). This may have great implications for schooling in South Africa.

The debate within many circles recently is no longer one which debates the positive and negative aspects of co-education versus single- sex schooling, but examines ways of monitoring and intervening in gender practices, including the hidden and overt curriculum in schools. This is seen by some as offering, perhaps, a better way of ensuring gender equality than by "packaging education into either a coeducational or single sex format" (Morrell 2000: 227).

Salomone (2003:239) sums up the debate by asking whether separating the sexes at certain points in the educational experience can alleviate to any degree the negative effects of the differences between boys and girls. She suggests that much of the research on single sex schools is inherently methodologically flawed, or that they are steeped within their specific cultural contexts, and that the evidence itself is not sufficient to provide definite conclusions. She states that there is no indication that single sex programmes harm students academically, and that the social drawbacks suggested are unsubstantiated. In fact, the evidence is that single sex schooling may potentially be quite positive. She reiterates that girls, in particular, benefit positively academically and "psychosocially" from single sex programmes, as they seem to provide girls with a greater comfort level that helps them to develop greater self confidence and broader interests. Single sex schools and classes also seem to promote less gender-polarised attitudes towards Mathematics and Science in girls. This may ultimately affect students to take non-traditional careers in the long-term.

2.3. Research studies on Girls' Achievement in Single Sex versus Co-educational Schools

2.3.1. Small-scale studies

Some of the research conducted to ascertain the effects of single sex versus co-educational schooling has been based mainly on small-scale qualitative case studies of teachers' and pupils' perceptions of the advantages and disadvantages of the two types of schooling. The results of these studies are not easily generalised, but may provide indications of the possible impacts of single sex schooling.

In 1982 Trickett et al found that the perceptions of students in single sex and co-educational secondary boarding schools in the United States were that single sex schools emphasize academics significantly more than co-educational schools (Streitmatter 1999:36).

Studies by Mahoney in 1985 found that girls in co-educational schools were subject to sexual harassment and dominance by boys, something that did not happen at single sex schools (Elwood & Gipps 1999:33). Also in 1985, a study by Riordan found that

girls were advantaged by the single sex environment in Catholic single sex schools, compared with those in public co-educational high schools (Streitmatter 1999:37).

Work was also carried out by the ILEA in 1985 in the United Kingdom which suggested that it was not possible to identify the reasons parents choose particular schools, and that it is related to the overall reputation of the school, rather than whether it is single sex or not. It was found, however, that many parents of daughters seemed to favour single sex schools (Elwood & Gipps 1999:41).

Hamilton studied high school students in Jamaica in 1985 and found that boys and girls in single sex schools performed better than those in co-educational schools, with girls in co-educational schools achieving the lowest performances (Streitmatter 1999:40).

A study conducted by Carpenter and Hayden in 1987 in Queensland and Victoria, Australia, found no difference for girls in single sex and co-educational schools in Queensland, regardless of the controlled variables. However, when school type and socio-economic status were used to explain school type difference, girls in single sex schools in Victoria performed better than the girls in co-educational schools (Streitmatter 1999:40).

A study by Rowe in Australia in 1988 found that vast differences by gender did not occur, but he did conclude that students in single sex classes demonstrated more confidence in Mathematics, and girls who moved from single sex classes to co-educational classes showed a loss of confidence (Streitmatter 1999:41).

In 1989, Marsh, Owens, Meyers and Smith conducted a longitudinal study in Australia, following the transition of a boys' and girls' school to form co-educational schools (Spielhofer et al 2002:13). This study found no measurable effect of the transition from single sex to co-educational schooling on the students' academic achievement. However, teachers interviewed as part of the study indicated that they believed that girls performed better in the single sex environment, although they saw the co-educational school environment as beneficial to girls' social development, including maturity, appearance and interpersonal behaviour (Spielhofer et al 2002:13).

He also found that boys and girls in single sex school had higher reading ability, and a greater number of foreign language and English credits (Streitmatter 1999:38). Bell conducted a study in England in 1989, and found that school type was not significant in determining achievement in general, or achievement by gender, once the selectivity of the single sex school was controlled (Streitmatter 1999:41).

In 1990, Riordan examined the effect of ethnic group differences as well as gender in comparing single sex and co-educational schools. His results suggested that single sex schooling was better for white females and male and female minority students (Streitmatter 1999:37, Riordan 1990:111). He suggests that arguments for co-educational schooling include economic efficiency and providing a social environment reflective of the modern world, while single sex schools provide better role models for the students and allow religious groups to maintain their traditional educational practices. He also suggests that single sex schools display less sex-bias although they promote traditional sex-role development, and have more order and control than co-educational schools (Riordan 1990:61). He states that the empirical evidence shows that students, especially girls, in single sex schools do better in terms of academic achievement (Riordan 1990:61).

Cairns in 1990 found that students at single sex schools in Northern Ireland showed better self-esteem and locus of control (Streitmatter 1999:41).

Gill, in 1993, compared the cognitive self-esteem of girls in co-educational schools with boys, and with girls in single sex schools. Most of the boys were found to rank themselves within the top half of the class. Girls in co-educational schools tend to rank themselves in the bottom half of the class, even when the teacher had identified the girls as top students. The students were not aware of their own ability, and lacked esteem. However, in single sex schools, girls were found to rate their positions within the class more accurately. Gill found that mixed classes work to affirm the boys' understanding of their merit, and undermine the girls' self-esteem whereas, in single sex classes, girls have a clearer understanding of their own ability (Elwood & Gipps 1999:32).

West and Hunter, in 1993 in the United Kingdom, found that a major sample of parents of children at co-educational schools saw no good reason for their children to be segregated by gender, and believed that mixed schools prepared their children better for adulthood and social interaction between boys and girls (Elwood & Gipps 1999:41). However, parents of children attending single sex schools were of the opinion that girls-only schools allowed the girls to develop more personal and academic confidence and allowed them to proceed at their own pace. Parents of children attending both single sex and co-educational schools agreed that at single sex schools, there are more examples of positive female role models with respect to leadership and study in traditional male subjects (Elwood & Gipps 1999:42).

According to Elwood & Gipps (1999:40), Colley, Comber & Hargreaves found in 1994 that the preference for less stereotyped subjects by girls in single sex schools was linked to their age. Younger girls (11 – 12 years) show a preference for the "male" stereotyped subjects such as Mathematics and Science. The preferences of older students (15 – 16 years), however, tend to be gender related, rather than related to school type differences. Colley et al suggest that it is possible that attitudes towards school subjects become more sex-stereotyped as girls progress through secondary school, and as they move through adolescence during which time their adult gender roles are anticipated (Elwood & Gipps 1999:40).

In 1996, OFSTED and EOS found, based on inspection evidence, that there was little assistance available to broaden the horizons beyond traditional and stereotypical expectations in girls' schools in average and disadvantaged areas (Spielhofer et al 2002:12). They also found that much depends on the socio-economic context of the schools, and the ability profile of the intake. They also stated that it is important to consider the background factors of the schools and the students if one is trying to determine which school is better for one group of students over another.

Robinson and Smithers in 1995 and 1997 found that it was difficult to substantiate whether single sex or co-educational schools were better, because single sex schools differ in important ways other than the fact that they only admit girls. These schools also tend to be highly selective in intake, have students from higher socio-economic backgrounds and generally have long-established traditions (Elwood & Gipps

1999:8). These factors, as well as prior ability, have been proven to be the most important predictor of success (Elwood & Gipps 1999:8). Social class is very strongly associated with achievement, regardless of gender and ethnic background (Elwood & Gipps 1999:17).

LePore and Warren used data from the National Educational Longitudinal Study of 1988 from Catholic single sex and co-educational schools in their study in 1997. Their finding was that there was no evidence to support the theory that girls were advantaged by school type in achievement, self-esteem or locus of control. They reflected that their results were quite different to previous studies because of the changing nature of demographics in Catholic high schools, where increased numbers of minority students and lay teachers may cause Catholic schools to resemble public schools more closely, and school type may not, then, be a significant variable. They also suggested that increased awareness of gender-equity issues in schools might mean that there are fewer gender-bias issues for girls (Streitmatter 1999:43).

Robinson and Smithers conducted a qualitative study in 1999 using a larger analysis of pupil-level data, and also found mixed evidence of advantages and disadvantages of single sex schooling. Students at a university in the United Kingdom reflected on their experiences at school, and saw single sex education as benefiting girls academically, but listed high levels of competitiveness and spitefulness as negative aspects of single sex schools. Girls attending single sex schools seemed to find adjusting to higher education more difficult (Spielhofer et al 2002:13). Both boys and girls from co-educational state schools rated co-educational schools as benefiting them from a social perspective rather than an academic perspective. Robinson and Smithers concluded that girls who attended single sex schools tended to have a view that the boys would have been a distraction and value having been pushed academically in the single sex environment (Elwood & Gipps 1999:37).

At a roundtable workshop amongst teachers in the United States in 1997, a number of conclusions were formed about single sex schooling. They suggest that there is no evidence that single sex education works or is better than co-education, that single sex educational programmes may produce positive results for some students in some settings, that the long term impact of single sex schooling is unknown, and that no

learning environment, single sex or co-educational, provides an escape from sexism (Morrell 2000: 223).

In 1998, a group of educationalists who had been involved in studies of single sex and co-educational schooling met at a meeting at the annual conference of the research on Women in Education Special Interest Group of the American Educational Research Association, culminating in the publication of a book for which those present at the meeting contributed chapters. They identified common themes emerging from their findings. Many of the authors found that "single sex and coeducational schooling can provide possibilities or constraints to students' achievement or future opportunities, and these outcomes depend to a great degree on how these forms of schooling are implemented" (Datnow & Hubbard 2002:7). A quote by Kruse states, "Sex-segregated education can be used for emancipation or oppression. As a method, it does not guarantee an outcome. The intentions, the understandings of people and their gender, the pedagogical attitudes and practices, are crucial, as in all pedagogical work" (Datnow & Hubbard 2002:7). A number of studies found that in order to realise gender equity, the organisation must have an explicit commitment to this in the organisation's practices including the curriculum and instructional strategies, and that it is not enough to have a philosophical commitment to gender equity. "Achieving gender equity means not only providing equal opportunity to both genders but also acknowledging the power differences that exist between men and women in society and looking for ways that educational institutions can alter these taken-for-granted patterns that often place women on unequal footing to men and lead to restrictive notions of masculinity and femininity" (Datnow & Hubbard 2002:7,8). Some of the chapters of this book are concerned with the ways in which sexism in society as a whole undermines efforts to foster and engender gender equity within schools. Finally, the authors generally see that making sense of the conflicting evidence regarding the effectiveness of single sex schooling is a struggle, as well as the problem that schools have in defining why a particular form of schooling (single sex or co-educational) is preferable for whom and under what conditions. The authors suggest, "These are thorny questions, which most often result in the answer, "It depends…" " (Datnow & Hubbard 2002:8).

2.3.1.1. Single Sex Classes in Co-educational Schools

Some co-educational schools are attempting to make the most of the advantages of both single sex and co-educational schooling by introducing separate classes for girls and boys in certain subjects. Some educationalists see this as the optimal solution, as it offers the academic advantages of single sex education and the social advantages of co-educational schools. It was originally introduced in an attempt to assist girls to achieve in male-dominated subjects, and is now being used to address underachievement of male students.

In a report by Sukhnandan et al. in England and Wales in 2000, it was found that girls in single sex classes are more confident and so participate more than in co-educational classes. It was also found that girls received more teacher attention because they did not have to spend time managing boys' behaviour. However, it was thought that girls were disadvantaged by failing to gain insight into the perspective of the boys (Spielhofer et al 2002:13).

A study by Jackson in 2002 in England found that girls were more confident in single sex classes, because they were more confident, were not made fun of if they made a mistake, and felt less embarrassed at obtaining low marks (Spielhofer et al 2002:14).

Arnot and Gubb in 2001 reported on a study carried out in three schools that had introduced single sex classes. The findings were that this approach is of particular benefit to underachieving boys (Spielhofer et al 2002:14).

2.3.2. Larger-scale studies

Several larger scale studies have been conducted into the effects of single sex schooling on student achievement.

In an extensive report for the EOC, as reported by Elwood & Gipps (1999:32,33), Bone suggested that research prior to 1983 indicated that girls in single sex schools did not have to compete with boys for teacher attention, did not have their abilities mocked by boys and were more confident to participate in class. However, it was

found that girls themselves do not see girls-only schools as a solution to these problems, tending to favour the introduction of single sex classes for certain subjects. It was also found that teachers treated girls and boys differently in class, tending to favour the role of the girl as a passive one.

Steedman carried out a major national study in English schools in 1985. It was based on a group of students (born in 1958), who passed through secondary schools during the middle of the 1970s. This research showed that girls and boys at single sex schools did better than boys and girls in co-educational schools, and that the students in single sex schools were already achieving better in Mathematics, Reading and in general before they entered secondary school. Steedman found that the difference in the examination results achieved could not be adequately explained by whether or not the schools were mixed, or single sex, once allowance had been made for the difference in the intake of the schools (Arnot et al 1998:45). This study is now dated, and patterns of achievement and gender differences have changed substantially since this study was carried out.

As reported by Spielhofer et al (2002:15), Lee and Bryk carried out an analysis of the effects of single sex and co-educational schooling using multivariate and regression analysis techniques in 1986. This was carried out by studies of private Roman Catholic secondary schools in the USA. They controlled for pupils' personal and family background, curriculum track and the schools' social make-up. Their findings were that girls benefit from single sex schooling, particularly in reading and Science. It was also found that girls in single sex schools were more likely to be associated with academically oriented peers, to do more homework and to be less stereotyped in their sex role attitudes than the students in co-educational schools (Spielhofer et al 2002:15, Streitmatter 1999:37). However, when Marsh reanalyzed this data in 1989, he found that the original research had not adequately controlled for pre-existing differences between students. He argues that "when appropriate controls were introduced, almost no differences … could reasonably be attributed to the effect of school type, and there was no tendency for the few differences that did exist to consistently favour students from single sex or co-ed schools" (Spielhofer et al 2002:15).

A study by Lee and Marks in 1992 involving a sample of more than 3000 boys and girls from independent schools suggested that the traditional structure of many independent schools lends itself to the preparation of girls for occupational and social status that is less than that of boys, although they do point out that opportunities for more equal social and occupational status for women are becoming available. In their 1994 study of secondary, independent, non-Catholic schools, they found that teachers tended to "talk down" to the girls, to reinforce hard, rather than correct, work and to create greater dependency in their students compared with teachers in boys' and co-educational schools. Their conclusion was that gender equity practices have the most positive effect on students in co-educational schools. This work is the only recent major study that suggests that girls-only groupings may disadvantage girls (Streitmatter 1999:39).

In 1992 Nuttal et al examined patterns of exam performance of 15 and 16-year-old students, controlling for gender, verbal reasoning ability, ethnicity and eligibility for free school meals (an approximate measure of social class and poverty) as well as for management (church or state) and status (independent, etc). The differences between the single sex and co-educational schools were found not to be significant. In 1993 the study was repeated, and girls were found to perform significantly better at single sex schools. In 1994, when the study was again repeated, there was again found to be no significant difference between the performances at single sex versus co-educational schools.

In 1992 in the United States of America, a report, "How Schools Shortchange Women" was published after being commissioned by the American Association of University Women Educational Foundation. This study, after the study of more than one thousand publications about girls and education, concluded that bias against females in co-educational schools is widespread, and that this was the "cause of lasting damage to both educational achievement and self-development" (Datnow & Hubbard 2002:11).

Another large-scale review of literature was done by Moore, Piper and Schaefer for the U.S. Department of Education. The review concluded that there was enough evidence to show that single sex schools may produce positive outcomes for girls, and

that there is not enough evidence for any argument against this (Datnow & Hubbard 2002:13).

Young, in 1994, reanalyzed data collected in 1983 in Australia from 233 schools. Science achievement was measured using a multiple-choice test. Young's conclusion, once again, was that socio-economic status and prior achievement are the two variables which most affect performance, rather than the type of school, or sex composition of the school (Spielhofer et al 2002:17).

Baker et al conducted a study in 1995 and found that the effects of single sex schooling are less noticeably different in countries in which there is a balance between single sex and co-educational schools (Elwood & Gipps 1999:30).

A study conducted by Kelly in 1996 in the United Kingdom identified significant advantages of single sex schooling. However, it is also limited because of the lack of measurement of individual students' prior ability and pupil level data. This research was based on the analysis of data of GCSE results linked with the proportion of Year 11 students entitled to free school meals. This was used as a control, and analysis of results indicated that girls and boys performed significantly better in single sex schools (Spielhofer et al 2002:16).

Daly, in 1996, reported on a study based on a reanalysis of public performance data obtained from surveys of students in Northern Ireland. Multilevel modeling was used, but the study was limited because of the small number of schools used. The finding was that the impact of co-educational schooling on girls' achievement was slightly negative, although none of the measured differences was statistically significant (Spielhofer et al 2002:17).

Hannan et al, in 1996, reported on a study done in Ireland. This study used multilevel modeling to examine the effect of single sex education on pupils' performance and personal and social development. A questionnaire survey was administered in 1994 and linked with the students' performance in examinations. The prior ability of the students was tested using Verbal Reasoning and Numerical Ability (DATS) tests. This study found that most of the differences for students aged 15 – 16, writing the

Junior Certificate, could be accounted for by pupils' social background and ability, although single sex schooling showed a slightly positive effect on girls' achievement, particularly those of lower ability, and particularly in Mathematics. No overall impact was identified in students aged 17 – 18 who wrote the Leaving Certificate. Also, it was found that students in co-educational schools had a more positive view of their schools' impact on their social and personal development than their peers in single sex schools (Spielhofer et al 2002:17, 18). Hannan et al found that girls have less confidence and lower senses of control than boys, no matter what school they attend, even though they have higher levels of achievement. It was also reported that girls are still subject to traditional gender stereotyping and carry a heavier domestic workload than boys, even at single sex schools (Elwood & Gipps 1999:35). The conclusions of this study are important, as it is the most comprehensive study done to examine the co-educational versus single sex issue. The data used is more contemporary than previous studies and the sample sizes were much larger. In Ireland, unlike elsewhere in the world, the single sex schools cater for a large proportion of the population, and not just a small, potentially distinctive minority. In summary, the findings of this study were that most of the differences in performance between co-educational and single sex schools were related to differences in social background and ability of the pupil intake when considering students aged around 14. The findings related to older students aged around 16 showed that schools differed markedly in general performance, but that these differences were related to the type of students attending the schools and the way in which the students were allocated to classes, rather than whether the school was single sex or not (Arnot et al 1998:46). This study was also significant because of the consideration of students' personal and social development, and not only the academic performance of the students.

In 1996, OFSTED and EOC reported the findings from statistical analysis done by OFSTED to show that girls and boys in single sex schools achieved slightly better GCSE results than those in co-educational schools, after controlling for socio-economic background by making use of available data such as free meal entitlement. A number of additional factors were suggested to account for the higher performance in single sex schools, including social class, parental support and a high proportion of students from ethnic minority groups (Spielhofer et al 2002:18).

The study carried out by Arnot et al in 1998 mentioned earlier also found that students in single sex and co-educational schools make different subject choices in their A-levels, and girls seem more likely to study Mathematics or Physical Science in single sex schools. It appears that the main reason for children choosing particular subjects is their prior performance in that subject. The different patterns of choice between different types of schools disappeared to a large extent when taking prior performance into account (Arnot et al 1998:49, 50). They also found that further research is needed to explore the "developmental antecedents" of anxiety in boys and girls and how this affects academic performance, that teachers' gender values and expectations play an important role in influencing students' perceptions or, and reactions to, school, that more research is needed on the effects of bullying and harassment on performance of both boys and girls and that gender values may play a role in the discrepancies evident in special needs provision and school exclusions, but that these values seem to be affected by the impact of ethnicity and social class (Arnot et al 1998:58, 60, 61, 62, 64). Regarding careers and occupational opportunities for males and females, Arnot et al (1998:67) found that these remain heavily influenced by gender. They suggest that gender is one of the key factors affecting academic performance, but that performance is also significantly affected by social class, ethnic origin and local context (Arnot et al 1998:72). The study also notes that single sex groupings seem to have very positive effects on students, although more information is needed on the long-term effects of these groupings (Arnot et al 1998:82). Arnot et al (1998:84) also mention the importance of ensuring the support of the entire staff for policies and principles that are applied within the schools in implementing a new set of values that address gender issues, and of maintaining the policy over a period of time.

Robinson and Smithers carried out a large-scale study in 1999 using national data supplied by the Department for Education and Employment, OFSTED and the Independent Schools Information Service. The research examined whether significant differences could be identified between the GCSE examination results of students in single sex and co-educational schools. This was done separately for independent and comprehensive schools. Their conclusions were that single sex education has less effect on the achievement of students than other effects. Again, a limitation of this

study was the lack of pupil-level data and the lack of measures of prior attainment (Spielhofer et al 2002:15).

In a review of recent research on the performance of girls in single sex schools, Elwood and Gipps (1999:51) reach a number of conclusions. Firstly, they suggest that academic performance is linked to factors other than whether or not a school is single sex. They suggest that the research shows that the better academic performance of girls in single sex schools is related to differences in intake that relate to social class and ability, and the histories and traditions of the schools. Most of the research agrees that the most useful predictors for academic success are social class and prior attainment. They also state that the research shows there to be a bigger difference in academic performance between the types of schools (whether it is independent, selective, comprehensive, etc) than whether they are single sex or co-educational. The research also suggests that the effect on student performance is different for different groups of students, and it seems that co-education has a bigger impact on lower ability students. Their report also supports the stance that academic performance is only one aspect of the complex debate about single sex schooling, and may be more or less important to different parents, teachers and children (Elwood & Gipps 1999:52).

The general conclusion reached by Elwood & Gipps (1999:55) is that there is no conclusive evidence to suggest that single sex schooling is better than co-educational schooling. They suggest that there are too many variables involved to support such a suggestion. They state that the research evidence supports the view that there is no general rule that one type of school is better than the other, and that there are many personal, social, cultural and religious reasons why parents choose particular types of schools for their children. They end by stating that parents must make their own choice with regard to type of school based on the individual child's needs and preference, in combination with their own preferences and the reputation of the school.

Four recent studies were conducted using a multilevel modeling approach. According to Spielhofer et al (2002:16), Harker published research conducted in New Zealand in 2000. The study was based on the analysis of data obtained in a longitudinal study of

students in 37 schools. The objective was to ascertain whether school type could account for the differences in achievement of Year 10 students, while controlling for prior attainment. The research showed that although girls at single sex schools achieved higher than their peers at co-educational schools, the difference could be accounted for by their higher prior attainment. Harker suggests that when adequate control is introduced for different levels of ability, and social and ethnic mix of the two types of schools, there is very little difference in the achievement of girls in single sex and co-educational schools (Spielhofer et al 2002:16). The weakness in this study was the small number of schools included in the study, as the results can be distorted by one or two outstandingly successful (or unsuccessful) schools.

A research project was carried out in 2002 by Spielhofer et al to identify the impact of school size and single sex education on secondary school students. The researchers carried out a "value-added analysis" of national performance data, using multilevel modeling techniques. They used matched pupil-level datasets. The findings of their research indicate that sex stereotyping in subject choices was reduced in single sex schools and that girls in single sex comprehensive schools performed better than girls in mixed comprehensives. The authors acknowledge that, although they controlled for many pupil- and school-level factors that were available, that there may be other relevant factors that are important that are not included, and because of this, it is possible that the differences could be explained by factors other than single sex schooling. They also noted that single sex schools tend to benefit because of high levels of parental support and commitment, and that they are often fully or oversubscribed. The schools are probably chosen by well-informed parents who are interested in their children's education. The background and heritage of individual schools may also be important factors in affecting performance (Spielhofer et al 2002:48,49). This study was of great importance, as it is one of the few research studies to have been recently undertaken that found that girls in single sex schools perform better than those in mixed comprehensives, even after controlling for background variables.

2.3.3. Research in Developing Countries, including South Africa

There is very little evidence to support either single sex or co-educational schools in developing countries.

In 1989, Jiminez and Lockheed found that girls achieved better in Mathematics in single sex schools during a study using longitudinal data on Mathematics achievement before and after 8th Grade in Thailand, but most single sex schools in Thailand are private, and most co-educational schools are public schools which, as Lee and Lockheed state, "results in an unavoidable but unfortunate confounding of school grouping and school governance in that study" (Lee & Lockheed 1989:3,9).

A study conducted by Lee and Lockheed in Nigeria in 1989 and 1990 concluded that single sex schooling was better for girls, particularly because of the safety of girls in these institutions and the fact that the girls would be less likely to fall pregnant at these schools (Lee & Lockheed 1989:11,37). Their study also showed that single sex-schools affect girls in Nigeria positively in increasing Mathematics achievement, and in engendering less sex-stereotypical views of Mathematics (Lee & Lockheed 1989:33). This was particularly significant, because of earlier research on education in Nigeria that suggested that girls were less likely to be educationally advantaged, and that single sex schools generally lacked resources (Lee & Lockheed 1989:33). However, once again, there was the problem of the small number of single sex schools available from which to collect data.

A study in Nigeria by Erinosho in 1997 indicates that single sex schooling appears to have played an important role in promoting the entrance of girls into careers in Science and Technology (Morrell 2000:229).

From a study in the Muslim countries of North Africa, it seems that girls-only schools have played a positive role in terms of providing positive role models for the girls, and lowering drop out levels and absenteeism (Morrell 2000: 229).

Elwood and Gipps (1999:29) advocate caution when considering findings of studies from developing countries, as comparison between schools within countries at

differing stages of development are difficult to interpret. Lee and Lockheed (1989:3,4,9) also mention how gender differences in school attendance rates make it difficult to accurately examine the effectiveness of schooling in terms of gender differences, as fewer females attend schools in East Africa, South Asia and Southern Europe. The girls that do attend school, therefore, tend to be a more socially and intellectually select group who come from more advantaged homes than the boys, and are likely to have more educated parents who are professionals. The lower level of girls' attendance in these countries is attributed to the role of marriage in the girls' lives as they mature. Governments in these countries are also less willing to invest in girls-only schooling, as educating girls is not seen as a high priority because their future role is in the home (Lee & Lockheed 1989:3).

South African schools have specific circumstances, particularly in terms of violence and sexual harassment, which has led to a recommendation by the Gender Equity Task Team (GETT) appointed in the late 1990s by the South African government to consider the establishment of single sex government schools for girls (Morrell 2000:221). Research suggests that single sex schooling in Africa may offer many of the advantages hoped for by feminists in first world contexts. However, single sex schools form a very small percentage of the schools within the South African education system, catering mostly for the elite part of the society (probably between 1 – 2 % of the population). Many of the new schools being established are co-educational, and some of the former white single sex schools are converting from single sex to co-educational (Morrell 2000:229).

2.4. Single Sex Schooling – impact on achievement in Physical Science

Although the gap between boys' and girls' achievement are narrowing in some areas, boys continue to outperform girls in the areas of Mathematics and Science (Arnot et al 1998:14).

There is no simple solution, and there are factors that count for and against both single sex and co-educational teaching. In the teaching of Science to girls, though, it seems that most studies that have been performed have shown that single sex schooling

raises academic results and improves the attitudes of girls in Science. In fact, single sex education may have a positive effect not only on the academic achievement of girls, but also on occupational achievement, self-image and career choice (Lee & Lockhead 1989:4).

Boys have been found to outperform girls in Science, although this is not consistent within different components of Science (e.g. Chemistry and Physics) or throughout the grades, and the difference in achievement in Science between boys and girls tends to increase throughout their schooling (Levin et al 1991:315). In the study of Levin et al (1991), their findings indicated a significant performance achievement difference in Science, which they attributed to the unequal science-related experiences and training of boys and girls, of cultural stereotyping of female role and career orientation, lower parental expectations and encouragement and a lack of stimulation and opportunity to explore scientific phenomenon at home and at school. This then leads to a lack of understanding in specific content area of science, although the underachievement in Science does not suggest a basic lack of understanding in general Science understanding, but rather a lack of self-confidence, lack of interest and low aspirations (Levin et al 1991:326). They suggest that girls' interest in Science needs to be progressively developed, and teachers and parents should challenge the false stereotypical views of Science at home and at school (Levin et al 1991:327).

Studies carried out by Harvey in 1985 in Britain found that there was very little difference in academic performance in Science between single sex and co-educational schooling, although girls in single sex classes in co-educational schools did better in physics than those in co-educational classes. His results, on the whole, suggested that girls in co-educational schools outperformed girls in single sex schools.

In 1989, a study was conducted by Bell by comparing the numbers of 15-year old boys and girls who chose to take Science, and comparing their achievement. The data was collected over a period of two years, from 1982 to 1984, and the effect of each school type was measured by calculating the mean test results for each school. The results of this study showed that, on average, boys and girls in single sex schools perform between 6 and 10 percent better on Science tests. However, there were no significant effects for students at comprehensive schools, once the independent and

grammar school results were excluded from the sample. These students were found to achieve better results because of their higher prior attainment, and higher socio-economic backgrounds, rather than the fact that they attended single sex schools. This study was limited because it did not control for different intake abilities within the various types of schools (Spielhofer et al 2002:14,15).

Fraser and Young carried out research in 1990 to look specifically at the effect of single sex schooling on students' Science achievement. They comment on the lack of participation of girls in the Science classroom, and the lack of women in Science professions. These effect were linked to the tendency of boys to lead in group activities in science class, the girls' perception of their lack of ability and the "masculinity" of the subject, as well as to the lack of parental and teacher encouragement of girls' participation in Mathematics and Physical Science (Young & Fraser 1990:5). Their review of research indicated that in England, the United States and Australia, girls achieved significantly higher in single sex schools, even when socio-economic status and school type were controlled. However, they state that the popular claim that single sex schools are superior to co-educational schools in reducing sex differences is not supported by convincing evidence from past research. In most countries, single sex schools tend to be private, whereas co-educational schools tend to be government, and so the theories are difficult to prove, and the influence of the independent school was found to be a factor that improved Science achievement (Young & Fraser 1990:17).

Young and Fraser (1990) attempted to statistically control for socio-economic status when examining sex differences in Science achievement, and had a problem in that no government schools in Western Australia are single sex, and the number of co-educational private schools is relatively small. The study indicated that the role of the school environment in influencing Science achievement is significant, as there appeared to be lower Science achievement among students attending government co-educational schools, compared with students attending independent co-educational schools (Young & Fraser 1990:18). Within the independent school sector, students attending single sex schools achieved higher Science results than students attending co-educational schools, although the sample size was not big enough to compare single sex and co-educational schools adequately.

Studies such as that carried out by Becker indicated that there was a significant average gender difference in general Science (Becker 1989: 162). The results of Young and Fraser, however, indicated that the differences in achievement of girls and boys in Science had very little to do with gender difference, but that the variation in achievement depended more on school effects (Young & Fraser 1994:869).

Research conducted by Stables in 1990 indicated that single sex education reduced the effect of sex-stereotyped choice of subject, especially in Physics, as reported by Spielhofer et al (2002:12). The study, involving 13 comprehensive schools in England, showed that students in co-educational schools tend to conform to a narrow, sex-stereotyped subject choice, thus narrowing their career choice (Spielhofer et al 2002:12, Elwood & Gipps 1999:39).

In 1995, a study was done on a section of a Physics class at the Illinois Mathematics and Science Academy. A girls-only section was offered as an experimental programme in Mechanics. The results of this study showed that more girls in the girls-only section of the Physics class enrolled in further calculus-based courses than ever before. The girls had higher levels of self-confidence than those in the co-educational section. They displayed better growth in performance on traditional classroom measures, particularly in problem solving and analysis. The teacher found that the degree of reflective practice within the classroom increased in response to the different classroom dynamics, as the climate of the classroom evolved into a very different one compared with the other classes. The classroom ethos was one in which there was “a profound sense of responsibility for learning – one’s own and each others’ learning”, “a special rapport between and among the students, which allowed for open exchanges”, “a spirit of co-learning” and “strong student influence on classroom dynamics” (Streitmatter 1999:42).

Much of the research that has been done has compared the achievement of girls in single sex schools with boys in single sex schools. Many of the studies that explicitly compare girls’ achievement in single sex versus co-educational schools have found that the lack of single sex schools in the pubic schooling sector made it difficult to ensure that all variables such as socio-economic factors, size of school, and others are comparable, because most of the single sex schools are private schools, where the

children are from wealthier, advantaged backgrounds. Nevertheless, there is evidence from studies that indicate that girls may benefit from single sex groupings in Science (Stables 1996: 166).

2.5. Conclusion

The literature reviewed suggests that co-educational schools are perceived to have a positive effect on the social and personal development of students, while single sex schools are seen to positively affect performance because of reduced stereotyped subject choices, increased confidence of girls and because teachers pay more attention to girls in single sex classes.

However, there was little to support these claims in the statistical studies that were performed to analyse the performance of students in mixed and single sex schools. Much of the research indicates that single sex schooling has a very small impact or none at all. Most studies that have been conducted have concluded that when the researcher has been able to statistically control for differences in ability and social class of the intake of students, the apparent difference in the academic performance between single sex and co-educational schools largely disappears. Students from lower socio-economic backgrounds continue to be disadvantaged generally, irrespective of whether the school is single sex or co-educational (Elwood & Gipps 1999:30).

Do single sex schools provide a better learning environment for girls? There is no definitive answer to this question from the literature. Some studies suggest that academic achievement, self esteem and locus of control is higher in single sex schools. Others find no difference in these effects whether the girls attend single sex or co-educational schools.

The research conducted and reported on in the following chapters attempts to answer the question of whether a single sex environment improves girls' performance in Science.

Chapter 3 Design and Methodology

The review of literature described in Chapter 2 formed the basis for decisions made concerning research design, sampling etc.

3.1. Research Design

This is a *post de facto study*, undertaken to examine whether the type of secondary school that girls attend (single sex versus co-educational) affects their achievement in Physical Science in Grade 12.

The research has been conducted in three ways, including the critical review and analysis of published literature relating to the topic, analysis of Grade 12 Physical Science Examination results in a number of independent single sex and co-educational secondary schools, and analysis of questionnaires that were completed by three Grade 12 girls attending a co-educational school and four Grade 12 Science students from a girls-only in order to compare their attitudes towards Physical Science.

3.2. Rationale for Research Design

The research was conducted in this way in order to ensure that enough valid information was obtained to be able to make informed conclusions as to whether or not girls perform better in Science in a single sex environment. The decision to conduct a comparison of a small group schools, chosen specifically to conform to certain criteria was taken in an attempt to control for various background variables that have been found to affect academic achievement. In controlling these variables as much as possible, the results should give an accurate indication of the single sex effect of schooling, rather than other effects such as socio-economic background. Most of the literature reviewed had to control for these variables statistically, because a wide variety of schools and students were used in the studies.

For the analysis of the data available when comparing the scores of matriculation examinations from various schools, there were a limited number of established co-educational schools available with similar numbers of girls taking Physical Science, and a limited number of schools that responded to the request for information. Because of this, it was necessary to interview some students attending single sex and

co-educational schools in order to explain some of the discrepancies that were observed during data collection. The objective thus was to examine what attitudes might have influenced the girls' subject choice with regard to taking Science in Grade 12. This was also a means of ascertaining whether the low numbers of girls taking Science in some co-educational schools was directly related to the fact that there are boys in the classroom, and whether girls were reluctant to take Science in this environment.

A *post de facto* approach was taken, as the research was designed to "explore possible causal relationships among variables that cannot be manipulated by the researcher" (McMillan & Schumacher 1997: 38, 39). As all the girls had written the same examination, at the same time, in the same amount of time, this should yield reliable information, and these results would have been adjusted statistically in order to ensure that the results achieved were in line with the results achieved by all schools writing these examinations in previous years. An *Ex Post Facto* was also deemed better at this stage because there would be more data available for analysis if the data from a number of years was considered, rather than from only one year.

Ideally, it would have been better to test the ability of the girls who wrote these examinations. In further research, this would perhaps be a more thorough way of conducting the research on this topic. The students whose achievements were used in this study were not available for pre-testing.

3.3. Subjects and sampling

The population from which the sample is drawn is a sample of Grade 12 girls attending a number of similar independent schools, who have chosen Physical Science as one of their matriculation subjects, and wrote the IEB Matriculation Physical Science Examination between 1999 and 2003.

The sample is a convenience sample as well as a stratified sample, including girls from schools with which the researcher has access to the data needed, and where the students were selected on the basis of the type of school attended. It includes all the girls who wrote the Physical Science Matriculation Examination in Grade 12 from

1999 to 2003. Unfortunately, some of the schools have only recently opened, and so results are only available for the years for which they have offered matriculation examinations to their students.

From the Independent Schools Association of South Africa publication listing all the independent schools in South Africa, schools in the Gauteng region were identified as conforming to the specific criteria that were necessary to ensure that as many background variables as possible were controlled. These included the size of the school, the area in which the school was situated (upper class and high socio-economic areas), religion (Catholic, Jewish and other schools were not considered) and school fees (only schools where the school fees were over R23000 per annum were considered).

In Gauteng, 7 girls-only schools were identified as having very similar school fees, socio-economic backgrounds, class size, religious and cultural ethos. Six of these schools responded to the questionnaire, and submitted data. Ten co-educational schools were identified as comparable to these girls-only schools in terms of socio-economic background (as measured by their school fees, and the upmarket areas in which they are situated), class size and religious and cultural ethos. Unfortunately, only four of these schools are long-established schools. Most of these schools have only been established in the last five to twenty years. Of these ten schools, only four responded positively to the request for information and submitted data. Of these four, three of the schools have only been established in the last ten years.

Because of the poor response in Gauteng, it was decided that the sample group should be widened to include similar schools from Kwazulu Natal, the Eastern Cape and the Western Cape. In Kwazulu Natal, six girls-only schools fit the criteria used to select the schools in Gauteng, and were contacted. Two of the schools replied and submitted data. Two co-educational schools meeting the same requirements were contacted. Both declined to assist with the research.

Two single sex and two co-educational schools in the Western Cape were contacted, but did not wish to assist with the research. One single sex school and one co-educational school in the Eastern Cape were contacted, but did not respond.

The fact that so few schools elected to assist in the submission of data for this study was problematic, especially considering the small sample size to begin with.

There were eight single sex and five co-educational schools who finally participated in the study. This included a total of 1 253 HG and 108 SG girls in single sex schools. There were, in contrast, only 168 HG and 55 SG girls in the five co-educational schools who took Science in Grade 12 during the past five years.

The data was then analysed in order to determine whether single sex schooling has an effect on Science achievement. Because of the small amount of data being analysed, it was possible to examine the trends and differences between the two types of schools fairly easily. Bonferroni (Dunn) t-Tests and Scheffe's Tests were used to statistically analyse the difference between the girls' achievement in single sex schools compared with those in co-educational schools in each year from 1999 to 2003. This was done separately for the Higher Grade and Standard Grade students.

Three Grade 12 girls who take Physical Science from the co-educational school (School J) submitted the questionnaire. One of these is a high Science achiever, one achieves average results, and the other does not usually achieve very well in Science. Four Grade 12 Science students from the girls-only school (School A) completed the questionnaire, two top achievers, one average to above average achiever, and one student who battles with Science.

All the girls writing these examinations would have been 17 or 18 years of age. The schools chosen were those at which the girls are from similar economic and social backgrounds, living in similar urban conditions and whose parents are educated and employed or self-employed. This was an extremely important criterion that was also very difficult to satisfy without having pupil-level data available on the girls who have written these examinations. It is widely stated in the literature that ethnicity, socio-economic and family background and family support and parent occupation are the factors that seem to have the most influence on academic achievement. In order to try to ensure that the students in this study had similar backgrounds in this regard, only similar independent schools were chosen.

Independent schools were initially chosen because most single sex schools are independent. This caused problems when selecting co-educational schools to participate in the study, because of the small number of established co-educational schools. However, had a sample of government schools been selected, there would have been very few single sex schools to use. The schools were all located in wealthy areas, and most of the students who attend these schools are from moneyed backgrounds. The schools chosen are all schools for which the school fees are between R23 000 and R40 000 per year.

Because many of the independent schools are single sex schools, the numbers in these schools limit the sample size that can be used to represent girls at co-educational schools. However, this should not affect the mark distribution within a sample.

Many of the schools have a history of tradition, although this is more evident in the single sex schools than the co-educational schools. The class sizes are small, and not more than 24 students are taught in any of the classes used.

It was not possible to control for prior achievement and student ability. It does seem, however, that the students in these schools are from backgrounds where the parents are concerned that the children attend good schools, and the parents themselves are educated or entrepreneurs. These schools are full or oversubscribed, and so the student body is, to some extent, selective. Therefore, the general ability of the students attending the school is relatively high. Also, because of the nature of the subject Physical Science, and it being an optional subject in each case, most of the children who would have elected to take Physical Science as a subject would have to be of average or above average intelligence, and have some mathematical aptitude.

Although the sample selection was done carefully in order to ensure that the students selected had similar backgrounds and experiences within their schools, it is acknowledged that there may be factors influencing performance which even the most robust statistical analysis may not be able to take into account.

3.4. Procedures Used

The validity of the data used for analysis is good, because the girls have all written the same examination, and because it is testing the achievement of girls in Science. The researcher has attempted to ensure the reliability of the results achieved in the analysis of data in this study by controlling the relevant variables mentioned previously.

The study was conducted by collecting the results of girls who have written the IEB Matriculation Examination over the past five years. The schools chosen represent a similar number of single sex and co-educational schools. They were chosen in such a way that variables such as socio-economic background, class size and teacher expertise are as similar as possible.

The Heads of these schools were consulted about whether they had any objection to the release of results achieved by girls in their schools over the past five years. They were informed in a letter that these results would be anonymous, that no child's results would be published independently in such a way that they could be identified, and that the schools would be referred to using labels which in no way give any indication of which school is represented. The results are presented in such a way that they do not discriminate against any particular type of school, because the researcher acknowledges the limitations of the results obtained in this dissertation as being of a very small sample group and specific to only one area (achievement of girls in Physical Science) of a very complex arena of educational debate.

A letter was sent to each Head, and in some cases the information required was faxed or e-mailed. In some instances it was necessary to go to the schools personally to collate the information. A questionnaire was completed with information as to the results of the students, and class sizes. Information that was already available was not requested. For example, information as to school fees, numbers of students in the school, date of establishment of the school are all available either on the Internet, or in a booklet issued by the Independent Examinations Board to all Independent Schools. This information has been used in the data analysis, even though it does not appear on the questionnaire.

Once the data had been received, it seemed that there were some discrepancies in the numbers of girls taking Science in some of the schools. To try to explain this in a more informed way, questionnaires were sent to girls in a single sex school, as well as two co-educational schools. The responses to these questionnaires have been analysed.

3.5. Instrumentation

3.5.1. Physical Science Achievement Instrument

The instrument used to measure girls' achievement in Physical Science in Grade 12 was the Independent Examinations Board Matriculation Examination that was written by all of these students in the years 1999 to 2003. This instrument was chosen for this study because the sample size was very small. This instrument had been written over a number of years, and so more data was made available for analysis than if a single administration of another instrument had been carried out. Also, this instrument was administered under controlled and standard conditions for all the students. The results achieved in these examinations have already been statistically adjusted to ensure that they are of a similar standard every year, and the effects of changing the examination every year have already been made negligible.

Furthermore, the testing instrument is not merely testing intellectual ability, but also the amount of learning that has taken place. The girls' understanding of the work and skills covered, as well as the preparation that has been done is being tested. All the students have had a similar chance of being introduced to the work, and preparing for the examination. Some other instruments might only have tested the intellectual ability of the students, while others may have included content or contexts to which not all the students would have been exposed to the same extent.

3.5.2. Questionnaire A: to gather results of examinations

The questionnaire used to gather the information from the various schools, Questionnaire A, and the letter that was sent to the Heads of schools appears in Appendix A and B. As mentioned previously, some of the information necessary was already available from other sources, and so was not requested in Questionnaire A. This information was used to select the schools initially, and included the school fees

of the school, the area in which the school is situated, the year in which the school was established, the number of students in the school and the Grades taught within the school.

The results required were of a sample of girls who wrote the IEB Matriculation Examination in Physical Science from 1999 to 2003. The results include both Physics and Chemistry as a combined mark. The results achieved by Higher Grade and Standard Grade students were collated and analysed separately.

3.5.3. Questionnaire B : for students

The questionnaire that was used to gather more qualitative data to explain some of the discrepancies in the results achieved in some of the schools is included in Appendix C as "Questionnaire B: for students". This was issued as a means of ascertaining whether the low numbers of girls taking Science in some co-educational schools was directly related to the fact that there are boys in the classroom, and whether girls were reluctant to take Science in this environment.

3.6. Data analysis and presentation

3.6.1. Analysis of Examination Results

The data collected from the schools was collated into Table 1 and Table 2, which may be found in the next Chapter. For each school, the results obtained in the years from 1999 to 2003 (unless the schools had not entered candidates in those years), were analysed in order to find the average mark achieved, the highest and lowest marks achieved by a girl in the Grade 12 year, the number of girls who wrote the examination, as well as the standard deviation of the results. A breakdown of the number of girls achieving A, B, C, D and E symbols was also done.

The results were then further analysed by comparing the results obtained by girls in the single sex and co-educational schools each year, from 1999 to 2003. A comparison of the results achieved in the single sex and co-educational schools was then collated into Table 3 and 4 and show the results of the statistical analysis that

was done using the Bonferroni (Dunn) t-Test and Scheffe's. These tables may be found in Chapter 4.

3.6.2. Analysis of Student Response to Questionnaires

A sample of girls was given Questionnaire B: for students, included in Appendix C as discussed previously. The following questions were asked:

1. Do you like Science?
2. Do you intend taking Science in any form at University?
3. Why did you choose Science as a subject, and would you make the same choice again?
4. Do you think girls are as good at Science as boys?
5. Do you feel comfortable asking and answering questions, and do you get attention in class?
6. Do you participate in Practical work?
7. Perceptions about girls in Science careers, and their perceptions of their teachers' and parents' support of girls in Science
8. Are you good at Science?
9. What changes would you make to the Science syllabus or to the Science class?

Their responses were analysed for each question asked. This is detailed in Chapter 4.

Chapter 4 Results and Interpretations

4.1. Results of analysis of examination results

4.1.1. General analysis of data collected

In Table 1 and Table 2 below, the results that were achieved in the thirteen schools during the years 1999 to 2003 have been collated. Table 1 shows the results of each school per year in the single sex schools. Table 2 shows the results of each school per year in the co-educational schools.

Table 1. Comparison of Single Sex Schools' Results

School		A		B		C		D		E		F		G		H	
Single sex / Co-ed.		Single sex															
School fees		> 35000		> 35000		>30000		> 35000		>35000		> 30000		>30000		>25000	
Region		Gauteng		Gauteng		Gauteng		Gauteng		Gauteng		Gauteng		K-Natal		K-Natal	
Age of school		>50		>100		>100		<10		>100		>100		>100		>100	
Average number of students in the school		350		390		450		480		380		390		200		225	
ave. no of girls per Science class		15		16		16		24		17		17		15		14	
Per Year		HG	SG	HG	SG	HG	SG	HG	SG	HG	SG	HG	SG	HG	SG	HG	SG
1999	average:	64.2	47.8	70.2	62.7	72.5	68.3	63.5	61.3	70.9	70.0	67.0	59.0	67.9		66.1	71.0
	number:	14.0	4.0	47.0	6.0	45.0	3.0	39.0	3.0	33.0	1.0	12.0	6.0	21.0	0.0	14.0	1.0
	SD:	10.9	10.8	11.3	7.6	12.2	7.8	12.0	11.5	11.5		9.9	14.8	11.3		13.6	
	max. mark:	80.0	63.0	89.0	73.0	92.0	77.0	87.0	73.0	90.0	70.0	81.0	75.0	83.0		88.0	71.0
	min. mark	47.0	40.0	47.0	52.0	48.0	62.0	40.0	50.0	41.0	70.0	47.0	33.0	40.0		45.0	71.0
	no. of A's:	2.0	0.0	11.0	0.0	17.0	0.0	4.0	0.0	9.0	0.0	2.0	0.0	3.0		3.0	0.0
	no. of B's:	3.0	0.0	18.0	1.0	12.0	1.0	6.0	1.0	14.0	1.0	4.0	1.0	8.0		3.0	1.0
	no. of C's:	5.0	1.0	10.0	3.0	8.0	2.0	12.0	1.0	3.0	0.0	4.0	3.0	7.0		3.0	0.0
	no. of D's:	2.0	0.0	5.0	2.0	6.0	0.0	12.0	1.0	6.0	0.0	1.0	2.0	1.0		3.0	0.0
	no. of E's:	2.0	3.0	3.0	0.0	2.0	0.0	5.0	0.0	1.0	0.0	1.0	0.0	2.0		2.0	0.0
2000	average:	73.2	73.3	63.2	68.0	69.0	56.0	68.7	58.6	74.7	74.3	71.5	60.0	70.9	65.5	70.9	71.5
	number:	16.0	3.0	55.0	1.0	35.0	1.0	43.0	5.0	30.0	3.0	34.0	4.0	16.0	2.0	12.0	2.0
	SD:	11.5	4.6	11.5		13.2		12.7	13.1	12.9	6.1	11.0	16.5	10.8	2.1	12.2	12.0
	max. mark:	91.0	76.0	86.0	68.0	97.0	56.0	91.0	70.0	95.0	81.0	88.0	80.0	87.0	67.0	98.0	80.0
	min. mark	55.0	68.0		68.0	47.0	56.0	54.0	40.0	49.0	69.0	46.0	40.0	46.0	64.0	55.0	63.0
	no. of A's:	6.0	0.0	6.0	0.0	12.0	0.0	12.0	0.0	14.0	1.0	9.0	1.0	3.0	0.0	3.0	1.0
	no. of B's:	3.0	2.0	10.0	0.0	2.0	0.0	10.0	1.0	3.0	1.0	11.0	0.0	7.0	0.0	4.0	0.0

	no. of C's:	5.0	1.0	16.0	1.0	9.0	0.0	8.0	2.0	10.0	1.0	9.0	1.0	4.0	2.0	3.0	1.0
	no. of D's:	2.0	0.0	17.0	0.0	10.0	1.0	11.0	1.0	2.0	0.0	4.0	1.0	1.0	0.0	2.0	0.0
	no. of E's:	0.0	0.0	6.0	0.0	1.0	0.0	2.0	1.0	1.0	0.0	1.0	1.0	1.0	0.0	0.0	0.0
2001	average:	68.3	53.0	70.4	48.0	66.7	69.0	64.7	40.0	67.3	75.6	66.9	63.8	72.7	90.0	68.9	
	number:	16.0	1.0	42.0	1.0	39.0	3.0	46.0	2.0	34.0	5.0	34.0	6.0	29.0	1.0	17.0	0.0
	SD:	12.4	n/a	12.9		12.6	2.6	10.8	0.0	12.6	7.9	12.5	6.1	9.7		10.1	
	max. mark:	84.0	53.0	93.0	48.0	90.0	72.0	83.0	40.0	88.0	83.0	87.0	71.0	89.0	90.0	84.0	
	min. mark:	46.0	53.0		48.0	42.0	67.0	43.0	40.0	42.0	64.0	40.0	40.0	50.0	90.0	42.0	
	no. of A's:	4.0	0.0	13.0	0.0	8.0	0.0	4.0	0.0	7.0	3.0	6.0	0.0	8.0	1.0	3.0	
	no. of B's:	5.0	0.0	10.0	0.0	9.0	1.0	14.0	0.0	5.0	1.0	8.0	1.0	8.0	0.0	5.0	
	no. of C's:	5.0	0.0	12.0	0.0	9.0	2.0	12.0	0.0	9.0	1.0	12.0	2.0	11.0	0.0	7.0	
	no. of D's:	5.0	1.0	5.0	0.0	10.0	0.0	12.0	0.0	6.0	0.0	5.0	2.0	2.0	0.0	1.0	
	no. of E's:	1.0	0.0	2.0	1.0	3.0	0.0	4.0	2.0	2.0	0.0	3.0	1.0	0.0	0.0	1.0	
2002	average:	70.3		72.6		72.3	54.5	66.7	51.0	61.9	58.3	67.0	71.8	67.6	59.0	76.6	42.0
	number:	23.0	0.0	42.0	0.0	41.0	2.0	55.0	1.0	43.0	6.0	35.0	6.0	25.0	1.0	14.0	1.0
	SD:	13.4		15.2		12.6	20.51	12.2		12.4	20.7	12.4	5.0	12.5		10.5	
	max. mark:	98.0		97.0		99.0	69.0	94.0	51.0	91.0	89.0	94.0	77.0	92.0	59.0	92.0	42.0
	min. mark:	47.0				40.0	40.0	44.0	51.0	43.0	33.0	47.0	34.0	44.0	59.0	60.0	42.0
	no. of A's:	6.0		18.0		14.0	0.0	9.0	0.0	3.0	1.0	5.0	0.0	5.0	0.0	6.0	0.0
	no. of B's:	5.0		7.0		11.0	0.0	13.0	0.0	6.0	0.0	11.0	2.0	6.0	0.0	3.0	0.0
	no. of C's:	7.0		6.0		8.0	1.0	18.0	0.0	11.0	2.0	8.0	2.0	6.0	0.0	5.0	0.0
	no. of D's:	3.0		7.0		6.0	0.0	9.0	1.0	8.0	1.0	9.0	1.0	6.0	1.0	0.0	0.0
	no. of E's:	2.0		4.0		2.0	1.0	6.0	0.0	9.0	1.0	2.0	0.0	2.0	0.0	0.0	1.0
2003	average:	75.4	48.0	67.9	56.7	69.5	59.2	68.9	59.8	61.9	57	70.3	71.3	73.3	65.7	61.7	80.0
	number:	17.0	1.0	33.0	7.0	40.0	5.0	53.0	5.0	37.0	1.0	36.0	4.0	26.0	3.0	10.0	1.0
	SD:	7.8	n/a	12.4	14.0	15.5	13.7	14.1	6.38	12.2		11.6	13.9	11.3	10.0	10.2	
	max. mark:	92.0	48.0	92.0	73.0	91.0	72.0	92.0	68.0	90.0	57.0	96.0	84.0	87.0	76.0	77.0	80.0
	min. mark:	64.0	48.0		40.0	40.0	40.0	40.0	51.0	40.0	57.0	41.0	56.0	50.0	56.0	48.0	80.0
	no. of A's:	5.0	0.0	9.0	0.0	13.0	0.0	16.0	0.0	3.0	0.0	8.0	2.0	12.0	0.0	0.0	1.0
	no. of B's:	7.0	0.0	4.0	1.0	11.0	2.0	12.0	0.0	8.0	0.0	14.0	0.0	7.0	1.0	2.0	0.0
	no. of C's:	5.0	0.0	11.0	2.0	4.0	1.0	10.0	3.0	12.0	0.0	9.0	1.0	2.0	1.0	3.0	0.0
	no. of D's:	0.0	0.0	8.0	1.0	6.0	1.0	9.0	2.0	9.0	1.0	4.0	1.0	5.0	1.0	3.0	0.0
	no. of E's:	0.0	1.0	1.0	3.0	6.0	1.0	6.0	0.0	5.0	0.0	1.0	0.0	0.0	0.0	2.0	0.0

Table 2: Comparison of Co-educational Schools' Results

School		I		J		K		L		M	
Single sex / Co-ed.		Co-educational									
School fees		>35 000		>34 000		>35 000		>27 000		>23 000	
Region		Gauteng		Gauteng		Gauteng		Gauteng		Gauteng	
Age of school		<10		>95		<10		<10		>15	
Average number of students in the school		420		350		330		606		110	
ave. no of science students per class		8		17		15		20		20	
ave. no. of girls per science class		4		7		5		5		4	
Per Year		HG	SG	HG	SG	HG	SG	HG	SG	HG	SG
1999	average:			75.7	53.0					54.5	58.7
	number:			12.0	1.0					4.0	12.0
	SD:			8.6						11.0	9.5
	max. mark:			93.0	53.0					66.0	71.0
	min. mark:			65.0	53.0					40.0	43.0
	no. of A's:			5.0	0.0					0.0	0.0
	no. of B's:			2.0	0.0					0.0	2.0
	no. of C's:			4.0	0.0					1.0	5.0
	no. of D's:			0.0	1.0					2.0	2.0
	no. of E's:			0.0	0.0					1.0	3.0
2000	average:			70.8	72.5	69.5		54.2	42.3	59.0	59.8
	number:			12.0	2.0	2.0	0.0	9.0	3.0	3.0	10.0
	SD:			10.6	10.6	26.2		12.9	10.7	2.0	10.9
	max. mark:			92.0	80.0	88.0		80.0	54.0	61.0	80.0
	min. mark:			56.0	65.0	51.0		40.0	33.0	57.0	45.0
	no. of A's:			4.0	1.0	1.0		1.0	0.0	0.0	1.0
	no. of B's:			2.0	0.0	0.0		0.0	0.0	0.0	0.0
	no. of C's:			5.0	1.0	0.0		1.0	0.0	1.0	5.0
	no. of D's:			1.0	0.0	1.0		4.0	1.0	2.0	2.0
	no. of E's:			0.0	0.0	0.0		3.0	1.0	0.0	2.0
2001	average:			73.8		51.4		57.6	50.7	54.0	49.5
	number:			17.0	0.0	7.0	0.0	9.0	3.0	5.0	2.0
	SD:			8.7		12.2		11.9	11.0	7.1	10.6
	max. mark:			88.0		75.0		79.0	62.0	66.0	57.0
	min. mark:			54.0		40.0		40.0	40.0	48.0	42.0
	no. of A's:			6.0		0.0		0.0	0.0	0.0	0.0
	no. of B's:			6.0		1.0		2.0	0.0	0.0	0.0
	no. of C's:			4.0		0.0		2.0	1.0	1.0	0.0
	no. of D's:			1.0		2.0		3.0	1.0	3.0	1.0
	no. of E's:			0.0		4.0		2.0	1.0	1.0	1.0
2002	average:	58.3		71.9	67.0	56.2	38.0	57.4	53.0	59.8	57.0
	number:	8.0	0.0	11.0	1.0	5.0	1.0	17.0	3.0	4.0	2.0
	SD:	18.0		11.4		11.6		9.1	11.4	20.5	0.0
	max. mark:	76.0		88.0	67.0	69.0	38.0	69.0	61.0	89.0	57.0
	min. mark:	40.0		56.0	67.0	40.0	38.0	40.0	40.0	42.0	57.0
	no. of A's:	0.0		4.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0
	no. of B's:	3.0		2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	no. of C's:	1.0		2.0	1.0	3.0	0.0	8.0	1.0	0.0	0.0

	no. of D's:	1.0		3.0	0.0	2.0	0.0	6.0	1.0	2.0	2.0
	no. of E's:	3.0		0.0	0.0	0.0	0.0	3.0	1.0	1.0	0.0
2003	average:	69.8	51.3	77.3	78.0	76.2		64.1	52.8	60.5	51.0
	number:	4.0	4.0	8.0	1.0	5.0	0.0	22.0	6.0	4.0	4.0
	SD:	18.3	9.0	12.7		13.1		12.1	17.1	7.1	13.9
	max. mark:	89.0	61.0	92.0	78.0	85.0		89.0	74.0	71.0	68.0
	min. mark:	48.0	40.0	58.0	78.0	53.0		44.0	34.0	55.0	34.0
	no. of A's:	2.0	0.0	4.0	0.0	4.0		3.0	0.0	0.0	0.0
	no. of B's:	0.0	0.0	1.0	1.0	0.0		4.0	2.0	1.0	0.0
	no. of C's:	1.0	1.0	2.0	0.0	0.0		8.0	0.0	0.0	1.0
	no. of D's:	0.0	1.0	1.0	0.0	1.0		3.0	1.0	3.0	2.0
	no. of E's:	1.0	2.0	0.0	0.0	0.0		4.0	2.0	0.0	0.0

The most striking observation to be made at first glance about these tables is the lack of information available from co-educational schools, with only five schools out of the thirteen representing co-educational schools. Most of these schools are also relatively new schools, and so there are years for which no results are available. The problems associated with this have been discussed previously.

It would seem, too, that very few girls have elected to take Science as a matriculation subject in most of the co-educational schools. As mentioned earlier, there were a total of 1 253 HG and 108 SG girls taking Science in the 8 single sex schools from 1999 to 2003. There were, in contrast, only 168 HG and 55 SG girls in the five co-educational schools who took Science in Grade 12 during the past five years.

4.1.2. Analysis of Single Sex School Results

From Table 1, it can be seen that School A has fewer numbers of girls taking Science in Matric than the other single sex schools of the same size. On investigation it was found that this school, unlike the other schools, has no entrance requirements in terms of Academic competence, and no entrance examinations are written. This school caters for those girls who are re-entering the mainstream education system after having attended schools in which their learning problems could be addressed. There are, therefore, fewer numbers of girls who are able to cope with Science at this level. School F also appears to have fewer numbers of girls taking Science, although it was not possible to ascertain why this was so. School H has smaller numbers of girls taking Science, but this may be accounted for by the fact that the school as a whole is smaller than many of the other schools represented in this sample.

The range of marks achieved by girls in single sex schools is fairly similar across the schools. There is a good spread of symbols (A to E), with many of the girls doing very well. Although the averages achieved by School D tended to be fairly low compared with the other single sex schools, it did not always achieve the lowest results. This school was the only single sex school to have been recently established, and yet the results compare fairly favourably with the other single sex schools, and there are a large number of girls taking Science. Although this school was newly established, it was affiliated to a very well known and established boys' school.

4.1.2. Analysis of Co-educational School Results

As mentioned previously, the very low numbers of girls taking Science as a subject is striking. What is also evident is that the averages achieved by the recently established schools increases steadily as the schools become more established over the years. This seems to indicate that an important background variable in academic achievement is the length of time for which a school has been operating, and that the more established schools, with long-standing traditions achieve better academic results. This may also be because of improved intake of good students as the school makes a name for itself during the first few years of its establishment. The exception to this is School D, which, as mentioned previously, produced good results, and high numbers of students taking Science although it was only recently established. This may, however, have been due to the fact that it was affiliated to an established and well-known boys' school.

4.1.2. Analysis of Single Sex versus Co-educational School Results

Bonferroni (Dunn) t-Tests and Scheffe's Tests were carried out on the results achieved by the girls at single sex schools versus those at co-educational schools per year, from 1999 to 2003, for Standard Grade and Higher Grade students. The full results of this statistical analysis may be found in Appendix D and E. These results have been summarized in Tables 3 and 4 below.

Table 3 Statistical Analysis – Higher Grade

Year	Single Sex Schools		Co-educational Schools	
	Mean	Bon & Scheffe Groupings	Mean	Bon & Scheffe Groupings
1999	70.375	A	68.536	A
2000	69.088	A	63.577	B
2001	67.861	A	63.211	B
2002	68.620	A	61.178	B
2003	68.470	A	68.163	A

Table 4 Statistical Analysis – Standard Grade

Year	Single Sex Schools		Co-educational Schools	
	Mean	Bon & Scheffe Groupings	Mean	Bon & Scheffe Groupings
1999	60.348	A	58.231	A
2000	64.900	A	58.000	A
2001	64.056	A	50.200	A
2002	57.471	A	54.000	A
2003	61.962	A	53.600	A

From Table 3, it can be seen that the results achieved in 1999 and 2003 in single sex schools by the girls taking Higher Grade Physical Science are not significantly different, because the Bon & Scheffe Groupings are the same (they are represented by the same letter). However, in 2000, 2001 and 2002, girls in the single sex schools achieved significantly higher results than the girls in the co-educational schools.

Table 4 shows that the results achieved by Standard Grade students in co-educational and single sex schools were not significantly different at any time, as the Bon & Scheffe Groupings are the same for all years.

4.2. Results of analysis of questionnaire completed by students

4.2.1. Do you like Science?

In response to the first question about whether or not the girls enjoyed Physical Science, three of the girls – the top and middle achievers - from the single sex schools as well as the middle achiever from the co-educational school responded that they enjoyed Science all of the time. The reasons given for this were that the girls enjoyed the challenge offered to them by the subject.

The girls who did not achieve as well in Science from both the single sex and co-educational stated that they enjoyed it most of the time. The girl from the single sex school felt that the subject was a difficult, but interesting one, while the girl from the co-educational school felt that her level of enjoyment of the subject depended on the topic being covered.

The top achiever from the co-educational schools indicated that she enjoyed the topic most of the time, but that it depended on the topic being covered, as she found the theory tedious.

The responses received in the questionnaire indicate that the girls enjoyed Science whether the classes were mixed or not. The enjoyment of the subject seems to stem from the particular topic being covered for some of the top and middle achievers rather than whether there are boys in the class. The response of the girl in the single sex school who does not achieve as well in Science suggests that the level of enjoyment is also related to the level of success that the girls achieve in the subject.

4.2.2. Do you intend taking Science in any form at University?

None of the girls from the single sex school who completed the questionnaires are intending to pursue Science as a career, although there are others in their class who are. All three of the girls from the co-educational school intend taking Science courses at University. Two of them intend taking Bachelor of Science courses, with the top achiever majoring in Genetics and the lower achiever taking subjects such as

Botany, Geology, Zoology and Chemistry. The middle achiever intends taking Engineering at University.

Unfortunately, the small sample size may have yielded unsatisfactory results in the section related to pursuing Science as a career. The discrepancy in girls from the two different schools types taking Science at tertiary level may be due to the small sample size. Further research would have to be conducted in order to determine whether this was the result of an unfortunate selection of subjects. This is the most likely explanation. It may be that girls-only schools support and perpetuate the traditional sex-stereotyped career choices for females, as was suggested in some of the literature, but this would need to be investigated further before any conclusive statements could be made concerning this. It is also possible that the small percentage of girls entering pure Science courses, particularly in Physics, and Engineering is due to the stereotypical attitudes still prevalent in the broader community about the type of careers that are suitable for girls, and the fact that Science is still viewed by many (even the girls who have chosen Science careers) as a boys' subject.

This part of the questionnaire analysis is inconclusive and would need to be explored further.

4.2.3. Why did you choose Science as a subject, and would you make the same choice again?

All the girls from the single sex school indicated that the reason that they had chosen to take Science as a subject when choosing subjects in Grade 9 was because they believed that Science would "open more career doors" for them. The middle achiever also indicated that she had chosen Science because she enjoyed it.

The top achiever from the co-educational school chose Science only because she liked the subject. The middle achiever also chose the subject because she felt that it would "open more career doors", but also because she liked Science, and had to take Science because of the course she wished to pursue at University. She also added that she felt that Science had taught her important life skills such as logical thinking and the ability to apply information to new situations. The lower achiever also stated that she had

chosen the subject in order to “open more career doors”, but also felt that Science had helped her to understand and make sense of the world around her.

All the girls from both schools would have chosen to take Science as a subject, if they were given the choice again.

All the girls indicated that they felt that Science was an important subject to take in order to have more choices available to them when choosing their careers. Most of them enjoyed the subject, and all of them are happy that they chose Science as a subject, and would do so again. This was unanimous, irrespective of whether the classes were mixed or not.

4.2.4. Do you think girls are as good at Science as boys?

Two of the girls from the single sex schools indicated that girls are just as good at Science as boys, and that gender plays no role in this. One of the girls suggested that boys are better at, and enjoy Physics more than girls because they are more interested in cars and electricity and similar topics, while girls prefer Chemistry because it requires learning, which girls are good at. The other girl felt that in some sections of work boys seem more interested and scientifically minded, resulting in better results.

All the girls at the co-educational school believe that boys do better at Science than girls. The top achiever at the co-educational school felt that girls were better suited to Chemistry because it requires learning, while the boys are naturally better at Physics. The middle achiever indicated that boys are better at Science than girls, stating that girls could get marks that were as good as those of the boys, but that they had to work harder to achieve these results. She felt that boys understand the subject better. The lower achiever thought that boys seem more logical than girls.

It would appear from the responses to the question about whether girls and boys are equally capable in Science that girls in single sex schools may be less inclined to hold stereotypical views of Science, and especially Physics, being more suited to boys than girls. However, there was evidence of stereotypical attitudes towards the fact that boys are better at Science than girls at both schools. Interestingly, the girls from the

girls-only school appear to have less stereotyped attitudes towards girls in Science than the co-educational schools, but none of them have chosen to take Science at a tertiary level. Again, this is an avenue that would need to be explored more.

4.2.5. Do you feel comfortable asking and answering questions, and do you get attention in class?

The perception of all the girls was that they felt comfortable asking and answering questions, and that they received, in the case of the co-educational school, as much attention as the boys. Both of the teachers involved in teaching these girls were women, and it would be interesting to investigate whether this was still the case in those schools where the Science teacher was a man. Also, these are merely the perceptions of the students, and it would be necessary to observe the classes to confirm them.

4.2.6. Do you participate in Practical work?

All the girls indicated that they enjoyed participating in Practical work.

The girls from the single sex school indicated that they liked doing experiments and practical work, and that they felt equal to the other group members.

The girls from the co-educational schools also liked doing experiments and practical work, but two of them felt that the boys take over and dominate the groups in Practical work. This supports much of the literature reviewed for this dissertation. It is unclear to what extent this has affected the achievement of girls in these classes.

4.2.7. Perceptions about girls in Science careers, and their perceptions of their teachers' and parents' support of girls in Science

All the girls believed that girls could enter Science and Engineering careers. Two of the girls, one from the single sex and one from the co-educational school indicated that gender is irrelevant. One of the girls from the single sex school suggested that girls work harder than boys, which is why they would succeed in Science and Engineering careers. One of the girls from the co-educational school stated that girls would prefer to take ecological and medical courses within these careers.

Six of the seven girls believe that their parents support the idea that girls can do Science as well as boys, and that they can pursue Science careers. Only one girl indicated that her parents and teacher believed that boys are better at Science than girls, although they still encouraged pursuing Science, but not Engineering, careers for girls.

One of the girls in the single sex school has a father who is an engineer, but the others do not have parents who have scientifically based careers. Two of the girls in the co-educational school have parents in scientific careers, two of whom are doctors, and one of whom is involved in Chemistry.

Although the girls indicated that, on the whole, they and their parents and teachers believe that girls do as well in Science as boys, and are as able to pursue Science careers, there are still some stereotypical attitudes concerning the types of careers that would be considered suitable for girls. The indication from the girls at both schools, but particularly in the co-educational school, is that Engineering is suitable for men, and that women would prefer Science careers that are more nurturing such as Health Sciences.

The fact that most of the girls in the co-educational school who completed the questionnaire had parents with scientific backgrounds, compared with only one in the single sex school may provide some insight as to why the girls in the co-educational school have chosen to pursue Science careers. Role models from home and the community may be more important predictors of whether girls will choose Science careers than whether their classes are mixed or not.

4.2.8. Are you good at Science?

The top and middle achievers felt that they were good at Science, while the lower achievers felt that they were not good at Science. The top achievers at the single sex school felt that this was because they liked and understood the subject, although the middle achiever felt that she did not always understand the work.

The top achiever at the co-educational school indicated that the reason that she does well at Science is because she likes Science. The middle achiever suggested that she did well in Science because she understands and likes the subject, and because she works hard because she needs to achieve good results.

The girls had an accurate perception of how good they were at Science. This was irrespective of whether they were in mixed classes or not.

4.2.9. What changes would you make to the Science syllabus or to the Science class?

Two of the girls from the single sex school indicated that they would like to choose between Physics and Chemistry, as both of them preferred Physics. One of the girls from the single sex school would like to do more practical work. One of the girls from the co-educational school suggested that smaller classes would be better. The others felt that they would not make any changes.

It was interesting to note that the girls in the single sex school who would prefer to be able to choose between Physics and Chemistry would both choose to study Physics rather than Chemistry. This was a contradiction to the suggestions of the girls in the co-educational school that boys are better at and more interested in Physics than girls.

4.2.10. Summary of responses to questionnaire

In conclusion, it would appear that there are differences between the single sex and co-educational environments. It was most unfortunate that questionnaires were not completed by another co-educational school, as this would have provided more insight. The two schools represented in these questionnaires are very similar in almost every respect in terms of socio-economic background, tradition, class size, etc. This co-educational school also has comparable numbers of girls taking Science as the single sex schools, whereas the other co-educational schools have significantly fewer numbers of girls taking Science. The results of the two schools (School A and School J) in the examinations are also very similar.

The most striking differences between the responses in the questionnaires relate to the perception of Science as a boys' subject. This perception, particularly concerning the belief that boys have a better natural ability in Physics, dominated in the co-

educational school, although it was also evident to a small extent in the single sex school.

The other difference was in the fact that all of the girls from the co-educational school have chosen to continue with Science at university, while none of the girls from the single-sex school will be pursuing Science as a career. This difference might have been an effect of the selection process, and may have been coincidental. It may also have been due to the fact that most of the parents of the girls in the co-educational school are in Science careers, and that the role models that the girls have at home are more important predictors of whether or not girls will pursue Science careers than any school effects.

Another result of the administration of the questionnaire was the suggestion that girls in mixed classes experience Practical work in such a way that it is dominated by the boys. It does not seem that this affects the girls' enjoyment of the subject, or the achievement of the girls in the examinations.

The results of these findings are summarized in the next Chapter.

Chapter 5 Conclusions

5.1. Summary of results and findings

5.1.1. Conclusions drawn from literature study

Traditionally, boys have been shown to outperform girls in Science. Small-scale studies suggest that girls are more confident in single sex environments, receive more attention in these settings, and are less likely to make sex stereotyped subject and career choices. Some studies have shown (with the exception of Spielhofer et al) that although students attending single sex schools tend to achieve better results, these results do not differ significantly from those in co-educational schools after controlling for factors such as prior attainment and social background, amongst others. However, it seems, from the literature that girls in single sex schools are more likely to choose Science as a subject, and are more likely to continue to choose higher level Science courses as they advance in educational institutions. The research done by Spielhofer et al indicates that single sex schooling may very well have a positive affect on academic performance of girls, once background factors have been controlled.

5.1.2. Conclusions drawn from the analysis of results achieved in single sex and co-educational schools from 1999 to 2003

The analysis of the results achieved by the female Grade 12 Science students over the past five years reveals that the debate surrounding single sex and co-educational schools is not a straightforward one, and that there are many factors affecting girls' achievement in Physical Science.

It would seem from the analysis that, in general, single sex schools achieve better results in Science than the co-educational schools. This may be seen by the significant differences found by the administration of the Bonferroni (Dunn) t-Tests and Scheffe's Tests in 2000, 2001 and 2002. However, it is also important to note that in 1999 and 2003 there was no significant difference in the results achieved, and so there may be other factors that are more important predictors of achievement than whether the schools are mixed or single sex. Also, there were no significant

differences between the Standard Grade results at all, although this may be due to the small numbers of girls taking Science on the Standard Grade.

There are more girls taking Science at single sex schools than at co-educational schools. This may be due to the prevalence of stereotyped attitudes of Science as a "boys' subject" within co-educational schools and the fact that they believe that boys are better at Science than girls. It may also relate to the fact that the classes are dominated by boys and that girls may be reluctant to take Science when there are so few girls in the classes. It may also be related to feelings of inadequacy and lack of confidence in themselves to perform well in class, and a fear of appearing "stupid" in front of the boys in the class.

5.1.3. Conclusions drawn from the analysis of questionnaires administered to girls at School A and School J

The analysis of the questionnaires administered to the students indicates that there are differences in the classroom and in attitudes between the mixed and single sex classroom. The girls in the mixed schools had stereotypical beliefs that boys are better at and more interested in Science. They also experience the boys dominating Practical lessons and taking over these lessons. However, these factors do not seem to have negatively affected the achievement of the girls in Science, and there were more girls at the co-educational school who had chosen to pursue Science at a tertiary level than the girls at the single sex schools.

Analysis of the results achieved by Grade 12 girls in these schools over the last five years shows that girls may be less inclined to choose Science as a subject for Matriculation than girls at a single sex school.

5.2. Limitations of the design

The design of the research has been done in such a way as to control as many of the variables influencing achievement of girls in science so that the only variable manipulated is the type of school (single sex versus co-education) that the girls attend. However, it is extremely difficult to control all these variables, and differences do exist, such as ability of students, that cannot be controlled. This study compares the

results of girls' achievement in a quantitative way, but also attempts to examine the attitudes of girls towards the subject.

A severe constraint experienced was the lack of established co-educational independent schools with which to compare the many, very well-established single sex schools. The numbers of girls taking Science in these schools was generally low, and also offers a constraint to the results obtained. This was compounded by the poor response by schools that did not elect to participate in the study.

This dissertation was limited in that it did not look at subjects other than Science achievement, and was not concerned with the achievement of boys, or in comparing the girls' achievement with those of boys' achievement. It was also not concerned with examining the impact on many important issues of single sex education such as the impact on social and personal development, and on available opportunities within the schools. It was also not possible to measure the prior ability of the students.

5.3. Significance of the Study

The area of study in which single sex schooling or single sex classes within co-educational schools is one that is of great significance. It is important that girls be encouraged to take Science, and to pursue careers in Science.

This particular study is of significance because it has been done on a small scale, using schools carefully chosen so as to try to ensure that most of the background variables typically associated with improved performance are controlled in an attempt to directly assess the effect of the single sex environment on achievement. This is a very different approach to the studies discussed in the literature.

From this study, it would appear that girls in mixed classes, and to a lesser extent in single sex schools, still have traditional views concerning the suitability of the subject for girls. It is the girls' perception that boys are better at Science because they have a natural ability, whereas girls have to work harder to achieve comparable marks, and prefer Chemistry because it is work based on learning rather than understanding. These findings support the existing literature. The one finding that does not support

the literature is the evidence that more girls at the co-educational school were choosing Science as a career than at the single sex school. However, this may have been due to the small sample size and selection process, rather than having serious implications for the debate surrounding single sex versus co-educational schooling. It may also indicate the importance of role models in determining career choice, as most of the girls choosing to continue to pursue Science at tertiary level had parents who were in scientific careers. It may also indicate the willingness of girls in single sex schools to take Science as a subject, even though they may not need it for their careers, while girls in co-educational schools take the subject because they need Science for their tertiary studies.

It would appear from the analysis of the results achieved by girls in Schools A to M from 1999 to 2003 that girls achieve better in Science on the whole at single sex schools than in co-educational schools. However, the results were only significantly different in 2000, 2001 and 2002. In 1999 and 2003 the results were not significantly different. The results for the Standard Grade students were not significantly different for all five years.

It would seem that girls are more likely to take Science as a subject in a single sex environment, because of the small number of girls taking Science at co-educational schools when compared with single sex schools. This supports the available literature on the topic.

These results must, however, be seen in the context in which the study was carried out. The small sample size and lack of established co-educational schools makes it difficult to predict how generalisable the results are.

5.4. Recommendations for Further Studies

Because of the limitation of the scope of the research it is not possible to examine all the causes of the differences between single sex and co-educational environments, and why girls do not tend to have positive attitudes towards science.

The study could be extended by conducting more qualitative research such as attitudinal studies, as well as follow-up case studies of girls who have chosen Science as a career. The questionnaire could be distributed to more students to more accurately study girls' attitudes to Science and the likelihood of girls taking Science as a career.

If the co-operation of the Independent Examinations Board could be sought so that many more schools could be considered, and a larger sample group used, the validity of the study would be greatly enhanced.

It would be very beneficial to repeat this study using students who have lower socio-economic backgrounds, as it would seem from other studies that this is where the greatest difference in achievement can be seen when comparing single sex and co-educational schools. This would be particularly relevant in South Africa, as a developing country, with a history of Bantu education and a large number of disadvantaged people. Unfortunately, this would be difficult, because of the huge differences between schools such as these, the lack of facilities, trained teachers, etc.

It would also be useful to use the multi-modelling technique as was used in the research of Spielhofer et al in 2002, where pupil level data as well as school level data could be incorporated in the analysis. This information was not available for this dissertation. It was possible only to compare average achievement of students within schools.

There was also no way of measuring prior achievement of students because of the *ex post facto* nature of the research. Although this was deemed to be the best method of research for this particular study, it would be useful to repeat a similar study on students writing their Grade 12 examinations who have been pretested for their ability.

5.5. Overall conclusion

In conclusions, it would seem that "whether girls achieve better results in Physical Science in single sex environments as compared with co-educational classes in mixed

secondary schools" – the question that was posed as the research problem in the beginning of this report - is not an easy one to answer. The literature reviewed suggests that Science remains a male domain, where boys continue to outperform girls, are more likely to choose Science as a subject and are more likely to pursue Science careers. Much of the literature suggests that whether girls attend single sex or co-educational schools, there is little difference to their performance in Science. The research carried out by Spielhofer et al in 2002 and the findings of the research contained in this dissertation find enough evidence of improved performance and attitudes of girls in single sex schools towards Science to warrant further investigation.

The results of the quantitative analysis of girls' performance in Science in independent schools across South Africa from 1999 to 2003 shows that, in most years, girls taking Higher Grade Science in single sex schools performed significantly better than their peers in co-educational schools. The small numbers of girls taking Science in Grade 12 in co-educational schools is cause for concern.

The results gathered by the administration of the questionnaire suggest that girls who are taught in classrooms where boys are present think differently about Science and about girls' ability to succeed in Science. Certainly, girls in co-educational schools are less confident about their ability in Physics, and the boys tend to dominate Practical work.

It would seem, from the research contained in this dissertation, that girls generally perform better in Science and are more confident about their ability in Science in a single sex environment.

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D. APPENDICES

APPENDIX A: Letter sent to schools (template)

My address and date

The Head
School's name and address

Dear _____

Assistance with Data collection for Masters' Dissertation

I am currently competing a Masters in Education with specialization in Natural Science Teaching. In order to complete this degree, I shall be submitting a dissertation entitled "The Effect of Single sex Schooling on Girls' Achievement in Physical Science".

The dissertation is one of very limited scope, and by no means seeks to investigate the many variables involved in selecting between single sex and co-educational schooling for individual girls. The subject of this dissertation is merely to examine a very small aspect of this larger subject.

I was very surprised that very little research has been done on this particular topic. While many gender issues have been explored, the effect of teaching girls Physical Science in a girls' only environment compared with an environment in which there are boys has not been researched to any great extent. Qualitative research, including attitudinal studies and the like are outside the scope of this study.

I have selected a number of schools in Johannesburg on the basis that as many of the variables affecting academic achievement will be kept constant. I have chosen schools in which student background is as similar as possible, where the quality of education is similar, where class size is relatively small, and so on. The names of the schools and students will not be indicated in any way in this dissertation. The schools shall be referred to using letters of the alphabet, and the candidates shall be referred to

using numbers. I shall not discuss or reveal the content of the questionnaires with any person in such a way that the person would know to which school I was referring.

I would like to compare the results of Physical Science students in the IEB matriculation examinations in single sex schools with those in so-educational schools over the last five years. I have attached a questionnaire to this letter. I should be extremely grateful if you could ensure that this is completed by your Physical Science head of Department or your Head of Academics. If this is not possible, I should be happy to come to your school to compile the results from your records myself. Please reply by e-mail to tcarter@kingsmead.co.za or fax the information to me on (011) 880 7396.

Your assistance in this regard would be greatly appreciated. Should you be interested in seeing the results of this study, please indicate this on the questionnaire. I should be glad to send you a summary of the outcome of my dissertation.

Yours faithfully
Tracey-Ann Carter (Mrs)

APPENDIX B: Questionnaire sent to schools

QUESTIONNAIRE A

SCHOOL x

Details of Girls' Achievements in Physical Science as measured by the IEB Matriculation Examination for 1999 - 2003

Please delete where applicable:

I agree / do not agree that these results may be used in the quantitative analysis as detailed in the covering letter, provided the school's and candidates details are treated confidentially.

School is Single sex / Co-educational

Choice of Physical Science as a Subject is Mandatory / Optional

Please post / do not post a copy of the results of this dissertation.

Please complete:

Number of Physical Science Matriculation classes is usually: _____

Number of Physical Science Matriculation teachers: _____

Average number of Physical Science students per class: _____

Average number of girls per Physical Science class: _____

Please complete the following table, unless the information is available in another format.

Years	**1999**		**2000**		**2001**		**2002**		**2003**	
	HG	SG	HG	SG	HG	SG	HG	SG	HG	SG
No. of girl candidates:										
No. of candidates (total):										
	% achieved for Physical Science in IEB Matriculation Examination									
1										
2										
3										
4										
5										
6										
7										
8										

9										
10										
11										
12										
13										
14										
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44										
45										
46										
47										
48										
49										
50										

Signature / acknowledgement of Head: Date:

_____ _____

APPENDIX C: Questionnaire sent to some students

QUESTIONNAIRE B : FOR STUDENTS

School: _____

Please answer these questions as fully and honestly as you can. The answers that you write are in complete confidence.

Please place a cross over the block in the tables that most closely match your response.
If there is no response that matches your answer, you do not have to mark a block. Just write your own response beneath.
If there is more than one response that you think matches your own, you may mark more than one block.

1. Do you like Science?

No / Never	A little / Some of the time	Most of the time	Yes / Always

2. Explain your answer to number 1.

I find Science difficult	I find the subject matter difficult and / or boring	I enjoy the subject matter	I find Science easy most of the time	It depends on the topic we are covering	It depends on the teacher

Any other comments:

_____

_____

_____

_____

_____

_____

3. Do you intend taking Science in any form at University?

Yes	No	Maybe in the future

4. If your answer was “Yes” in number 3, indicate the Science courses you intend taking.

Course:

Bachelor of Science Majors:		Engineering Major:	Other:	Medicine Specialising:

Subjects:

Physics	Chemistry	Zoology	Botany	Geology
Other				

5. Why did you choose Science as a subject?

My parents wanted me to take Science	I thought it would open more career doors for me.	I like Science.	I needed to take Science in order to do my course at university.	I am good at it.	I wanted to prove that I could do it.

Any more comments:

_____

_____

_____

6. If you had to choose your subjects again, would you choose to take Science?

Yes	No

Explain:

_____

_____

_____

7. Do you think girls are as good at Science as boys?

Yes	No	In some sections of the work

Explain:

_____

_____

_____

8. Do you feel comfortable asking and / or answering questions in class?

Yes. Always.	No. Not at all.	Sometimes	Most of the time.

Explain:

_____

_____

_____

9. Does your teacher give you as much attention in class as everyone else?

Yes. Always.	No. Not at all.	Sometimes	Most of the time.

Explain:

My teacher does not like me.	I do not like my teacher.	I don't like to draw attention to myself.	I am too scared of asking a silly question or of getting the answer wrong.
The teacher tends to ask the boys the questions, and answer their question.	I enjoy participating in class and answering and asking questions.	I don't feel ridiculed or stupid when I ask questions, even when I get them wrong.	I am not that interested.

Other comments:

_____

_____

_____

10. Do you participate in practical work?

Yes	No	Sometimes.	Most of the time.

Explain:

I like doing experiments and practical work, and so I take part actively.	I am not interested / don't like practical work, and so I don't get involved.	I don't feel confident enough to take part.	I am confident when using the equipment and taking part.
The boys tend to take over the experiments.	The teacher tends to take over the experiment.	The clever students tend to take over the groups.	I feel equal in my group.

More comments:

_____

_____

_____

11. Do you think that girls can be engineers and scientists?

Yes	No

Explain:

_____

_____

_____

12. What do your parents, teachers and peers think about girls taking Science?

They think that girls can	They think that Science	They think that boys are	They think that Science	They think that girls are	They think that

do Science as well as boys.	is for boys.	better at Science than girls.	careers are more for boys than girls.	just as good at Science as boys.	girls can pursue Science as a career

Explain:

_____

_____

_____

_____

13. Are your parents in Science careers?

Yes	No

Explain:

_____

_____

_____

14. Are you good at Science?

Yes	No

15. Why / Why not?

I understand the subject matter.	I don't understand the subject matter	I like the subject.	I don't like the subject.	I need to get good marks, and so I work hard.	I don't need Science for my future career and so I don't work hard.
I am not clever.	I am intelligent and good at mathematics.	I think that girls are not as good as boys in Science.	I think that girls are just as good as boys in Science.	I like my teacher and he / she teaches well.	I don't like my teacher and he / she does not explain well

Any other comments:

16. If you were to make any changes to the subject content or to the class that you are in, what would they be?

Have boys in the class.	Not have boys in the class.	Have a different teacher.	Do more practical work.	Do less practical work.
Make the content more relevant and interesting.	Be able to choose between Chemistry and Physics.	Have bigger classes.	Have smaller classes	Keep everything the same.

Any other comments:

APPENDIX D: Results of Statistical Analysis – Higher Grade

Part 1 – Year 1999

The GLM Procedure

year=1999

Class Level Information		
Class	**Levels**	**Values**
type	2	coed single

Number of Observations Read	364
Number of Observations Used	240

Dependent Variable: hm

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	50.51905	50.51905	0.35	0.5551
Error	238	34421.46429	144.62800		
Corrected Total	239	34471.98333			

R-Square	Coeff Var	Root MSE	hm Mean
0.001466	17.51592	12.02614	68.65833

Source	DF	Type I SS	Mean Square	F Value	Pr > F
type	1	50.51904762	50.51904762	0.35	0.5551

Source	DF	Type III SS	Mean Square	F Value	Pr > F
type	1	50.51904762	50.51904762	0.35	0.5551

Level of type	N	hm	
		Mean	Std Dev
coed	16	70.3750000	12.9608385
single	224	68.5357143	11.9606444

Bonferroni (Dunn) t Tests for hm

Note: This test controls the Type I experimentwise error rate, but it generally has a higher Type II error rate than REGWQ.

Alpha	0.05
Error Degrees of Freedom	238
Error Mean Square	144.628
Critical Value of t	1.96998
Minimum Significant Difference	6.1307
Harmonic Mean of Cell Sizes	29.86667

Note: Cell sizes are not equal.

Means with the same letter are not significantly different.			
Bon Grouping	**Mean**	**N**	**type**
A	70.375	16	coed
A	68.536	224	single

Scheffe's Test for hm

Note: This test controls the Type I experimentwise error rate.

Alpha	0.05
Error Degrees of Freedom	238
Error Mean Square	144.628
Critical Value of F	3.88083
Minimum Significant Difference	6.1307
Harmonic Mean of Cell Sizes	29.86667

Note: Cell sizes are not equal.

Means with the same letter are not significantly different.			
Scheffe Grouping	**Mean**	**N**	**type**
A	70.375	16	coed
A	68.536	224	single

Part 2 – Year 2000

The GLM Procedure

year=2000

Class Level Information		
Class	**Levels**	**Values**
type	2	coed single

Number of Observations Read	364
Number of Observations Used	266

Dependent Variable: hm

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	712.35601	712.35601	4.50	0.0348
Error	264	41765.50865	158.20268		
Corrected Total	265	42477.86466			

R-Square	Coeff Var	Root MSE	hm Mean
0.016770	18.34876	12.57786	68.54887

Source	DF	Type I SS	Mean Square	F Value	Pr > F
type	1	712.3560078	712.3560078	4.50	0.0348

Source	DF	Type III SS	Mean Square	F Value	Pr > F
type	1	712.3560078	712.3560078	4.50	0.0348

Level of type	N	hm	
		Mean	Std Dev
coed	26	63.5769231	13.8655633
single	240	69.0875000	12.4354673

Bonferroni (Dunn) t Tests for hm

Note: This test controls the Type I experimentwise error rate, but it generally has a higher Type II error rate than REGWQ.

Alpha	0.05
Error Degrees of Freedom	264
Error Mean Square	158.2027
Critical Value of t	1.96899
Minimum Significant Difference	5.1133
Harmonic Mean of Cell Sizes	46.91729

Note: Cell sizes are not equal.

Means with the same letter are not significantly different.			
Bon Grouping	**Mean**	**N**	**type**
A	69.088	240	single
B	63.577	26	coed

Scheffe's Test for hm

Note: This test controls the Type I experimentwise error rate.

Alpha	0.05
Error Degrees of Freedom	264
Error Mean Square	158.2027
Critical Value of F	3.87692
Minimum Significant Difference	5.1133
Harmonic Mean of Cell Sizes	46.91729

Note: Cell sizes are not equal.

Means with the same letter are not significantly different.			
Scheffe Grouping	**Mean**	**N**	**type**
A	69.088	240	single
B	63.577	26	coed

Part 3 – Year 2001

The GLM Procedure

Class Level Information		
Class	**Levels**	**Values**
type	2	coed single

Number of Observations Read	364
Number of Observations Used	289

Dependent Variable: hm

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	713.62697	713.62697	4.83	0.0287
Error	287	42370.43531	147.63218		
Corrected Total	288	43084.06228			

R-Square	Coeff Var	Root MSE	hm Mean
0.016564	18.06774	12.15040	67.24913

Source	DF	Type I SS	Mean Square	F Value	Pr > F
type	1	713.6269724	713.6269724	4.83	0.0287

Source	DF	Type III SS	Mean Square	F Value	Pr > F
type	1	713.6269724	713.6269724	4.83	0.0287

Level of type	N	hm	
		Mean	Std Dev
coed	38	63.2105263	13.7667007
single	251	67.8605578	11.8925388

Bonferroni (Dunn) t Tests for hm

Note: This test controls the Type I experimentwise error rate, but it generally has a higher Type II error rate than REGWQ.

Alpha	0.05
Error Degrees of Freedom	287
Error Mean Square	147.6322
Critical Value of t	1.96826
Minimum Significant Difference	4.1629
Harmonic Mean of Cell Sizes	66.00692

Note: Cell sizes are not equal.

Means with the same letter are not significantly different.			
Bon Grouping	**Mean**	**N**	**type**
A	67.861	251	single
B	63.211	38	coed

Scheffe's Test for hm

Note: This test controls the Type I experimentwise error rate.

Alpha	0.05
Error Degrees of Freedom	287
Error Mean Square	147.6322
Critical Value of F	3.87406
Minimum Significant Difference	4.1629
Harmonic Mean of Cell Sizes	66.00692

Note: Cell sizes are not equal.

Means with the same letter are not significantly different.			
Scheffe Grouping	**Mean**	**N**	**type**
A	67.861	251	single
B	63.211	38	coed

Part 4 – Year 2002

The GLM Procedure

Class Level Information		
Class	**Levels**	**Values**
type	2	coed single

Number of Observations Read	364
Number of Observations Used	316

Dependent Variable: hm

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	2137.42742	2137.42742	12.08	0.0006
Error	314	55572.43018	176.98226		
Corrected Total	315	57709.85759			

R-Square	Coeff Var	Root MSE	hm Mean
0.037037	19.69130	13.30347	67.56013

Source	DF	Type I SS	Mean Square	F Value	Pr > F
type	1	2137.427419	2137.427419	12.08	0.0006

Source	DF	Type III SS	Mean Square	F Value	Pr > F
type	1	2137.427419	2137.427419	12.08	0.0006

Level of type	N	hm	
		Mean	Std Dev
coed	45	61.1777778	13.7927664
single	271	68.6199262	13.2220148

Bonferroni (Dunn) t Tests for hm

Note: This test controls the Type I experimentwise error rate, but it generally has a higher Type II error rate than REGWQ.

Alpha	0.05
Error Degrees of Freedom	314
Error Mean Square	176.9823
Critical Value of t	1.96755
Minimum Significant Difference	4.2135
Harmonic Mean of Cell Sizes	77.18354

Note: Cell sizes are not equal.

Means with the same letter are not significantly different.			
Bon Grouping	**Mean**	**N**	**type**
A	68.620	271	single
B	61.178	45	coed

Scheffe's Test for hm

Note: This test controls the Type I experimentwise error rate.

Alpha	0.05
Error Degrees of Freedom	314
Error Mean Square	176.9823
Critical Value of F	3.87124
Minimum Significant Difference	4.2135
Harmonic Mean of Cell Sizes	77.18354

Note: Cell sizes are not equal.

Means with the same letter are not significantly different.			
Scheffe Grouping	**Mean**	**N**	**type**
A	68.620	271	single
B	61.178	45	coed

Part 5 – Year 2003

The GLM Procedure

Class Level Information		
Class	**Levels**	**Values**
type	2	coed single

Number of Observations Read	364
Number of Observations Used	294

Dependent Variable: hm

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	3.46738	3.46738	0.02	0.8880
Error	292	50920.38636	174.38488		
Corrected Total	293	50923.85374			

R-Square	Coeff Var	Root MSE	hm Mean
0.000068	19.29917	13.20549	68.42517

Source	DF	Type I SS	Mean Square	F Value	Pr > F
type	1	3.46737997	3.46737997	0.02	0.8880

Source	DF	Type III SS	Mean Square	F Value	Pr > F
type	1	3.46737997	3.46737997	0.02	0.8880

Level of type	N	hm	
		Mean	Std Dev
coed	43	68.1627907	13.4941438
single	251	68.4701195	13.1563712

Bonferroni (Dunn) t Tests for hm

Note: This test controls the Type I experimentwise error rate, but it generally has a higher Type II error rate than REGWQ.

Alpha	0.05
Error Degrees of Freedom	292
Error Mean Square	174.3849
Critical Value of t	1.96812
Minimum Significant Difference	4.2895
Harmonic Mean of Cell Sizes	73.42177

Note: Cell sizes are not equal.

Means with the same letter are not significantly different.			
Bon Grouping	**Mean**	**N**	**type**
A	68.470	251	single
A	68.163	43	coed

Scheffe's Test for hm

Note: This test controls the Type I experimentwise error rate.

Alpha	0.05
Error Degrees of Freedom	292
Error Mean Square	174.3849
Critical Value of F	3.87350
Minimum Significant Difference	4.2895
Harmonic Mean of Cell Sizes	73.42177

Note: Cell sizes are not equal.

Means with the same letter are not significantly different.			
Scheffe Grouping	**Mean**	**N**	**type**
A	68.470	251	single
A	68.163	43	coed

APPENDIX E: Results of Statistical Analysis – Standard Grade

Part 1 – Year 1999

The GLM Procedure

Class Level Information		
Class	**Levels**	**Values**
type	2	coed single

Number of Observations Read	364
Number of Observations Used	36

Dependent Variable: sm

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	37.224916	37.224916	0.30	0.5872
Error	34	4213.525084	123.927208		
Corrected Total	35	4250.750000			

R-Square	Coeff Var	Root MSE	sm Mean
0.008757	18.68351	11.13226	59.58333

Source	DF	Type I SS	Mean Square	F Value	Pr > F
type	1	37.22491639	37.22491639	0.30	0.5872

Source	DF	Type III SS	Mean Square	F Value	Pr > F
type	1	37.22491639	37.22491639	0.30	0.5872

Level of type	N	sm	
		Mean	Std Dev
coed	13	58.2307692	9.2118931
single	23	60.3478261	12.0514378

Bonferroni (Dunn) t Tests for sm

Note: This test controls the Type I experimentwise error rate, but it generally has a higher Type II error rate than REGWQ.

Alpha	0.05
Error Degrees of Freedom	34
Error Mean Square	123.9272
Critical Value of t	2.03224
Minimum Significant Difference	7.8501
Harmonic Mean of Cell Sizes	16.61111

Note: Cell sizes are not equal.

Means with the same letter are not significantly different.			
Bon Grouping	**Mean**	**N**	**type**
A	60.348	23	single
A	58.231	13	coed

Scheffe's Test for sm

Alpha	0.05
Error Degrees of Freedom	34
Error Mean Square	123.9272
Critical Value of F	4.13002
Minimum Significant Difference	7.8501
Harmonic Mean of Cell Sizes	16.61111

Note: Cell sizes are not equal.

Means with the same letter are not significantly different.			
Scheffe Grouping	**Mean**	**N**	**type**
A	60.348	23	single
A	58.231	13	coed

Part 2 – Year 2000

The GLM Procedure

Class Level Information		
Class	**Levels**	**Values**
type	2	coed single

Number of Observations Read	364
Number of Observations Used	35

Dependent Variable: sm

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	408.085714	408.085714	2.59	0.1169
Error	33	5195.800000	157.448485		
Corrected Total	34	5603.885714			

R-Square	Coeff Var	Root MSE	sm Mean
0.072822	20.25713	12.54785	61.94286

Source	DF	Type I SS	Mean Square	F Value	Pr > F
type	1	408.0857143	408.0857143	2.59	0.1169

Source	DF	Type III SS	Mean Square	F Value	Pr > F
type	1	408.0857143	408.0857143	2.59	0.1169

Level of type	N	sm	
		Mean	Std Dev
coed	15	58.0000000	13.6172160
single	20	64.9000000	11.6975031

Bonferroni (Dunn) t Tests for sm

Note: This test controls the Type I experimentwise error rate, but it generally has a higher Type II error rate than REGWQ.

Alpha	0.05
Error Degrees of Freedom	33
Error Mean Square	157.4485
Critical Value of t	2.03452
Minimum Significant Difference	8.7197
Harmonic Mean of Cell Sizes	17.14286

Note: Cell sizes are not equal.

Means with the same letter are not significantly different.			
Bon Grouping	**Mean**	**N**	**type**
A	64.900	20	single
A	58.000	15	coed

Scheffe's Test for sm

Note: This test controls the Type I experimentwise error rate.

Alpha	0.05
Error Degrees of Freedom	33
Error Mean Square	157.4485
Critical Value of F	4.13925
Minimum Significant Difference	8.7197
Harmonic Mean of Cell Sizes	17.14286

Note: Cell sizes are not equal.

Means with the same letter are not significantly different.			
Scheffe Grouping	**Mean**	**N**	**type**
A	64.900	20	single
A	58.000	15	coed

Part 3 – Year 2001

The GLM Procedure

Class Level Information		
Class	**Levels**	**Values**
type	2	coed single

Number of Observations Read	364
Number of Observations Used	23

Dependent Variable: sm

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	751.212077	751.212077	3.74	0.0668
Error	21	4219.744444	200.940212		
Corrected Total	22	4970.956522			

R-Square	Coeff Var	Root MSE	sm Mean
0.151120	23.22171	14.17534	61.04348

Source	DF	Type I SS	Mean Square	F Value	Pr > F
type	1	751.2120773	751.2120773	3.74	0.0668

Source	DF	Type III SS	Mean Square	F Value	Pr > F
type	1	751.2120773	751.2120773	3.74	0.0668

Level of type	N	sm	
		Mean	Std Dev
coed	5	50.2000000	9.4445752
single	18	64.0555556	15.0742173

Bonferroni (Dunn) t Tests for sm

Note: This test controls the Type I experimentwise error rate, but it generally has a higher Type II error rate than REGWQ.

Alpha	0.05
Error Degrees of Freedom	21
Error Mean Square	200.9402
Critical Value of t	2.07961
Minimum Significant Difference	14.902
Harmonic Mean of Cell Sizes	7.826087

Note: Cell sizes are not equal.

Means with the same letter are not significantly different.			
Bon Grouping	**Mean**	**N**	**type**
A	64.056	18	single
A	50.200	5	coed

Scheffe's Test for sm

Note: This test controls the Type I experimentwise error rate.

Alpha	0.05
Error Degrees of Freedom	21
Error Mean Square	200.9402
Critical Value of F	4.32479
Minimum Significant Difference	14.902
Harmonic Mean of Cell Sizes	7.826087

Note: Cell sizes are not equal.

Means with the same letter are not significantly different.			
Scheffe Grouping	**Mean**	**N**	**type**
A	64.056	18	single
A	50.200	5	coed

Part 4 – Year 2002

The GLM Procedure

Class Level Information		
Class	**Levels**	**Values**
type	2	coed single

Number of Observations Read	364
Number of Observations Used	24

Dependent Variable: sm

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	59.723039	59.723039	0.25	0.6193
Error	22	5174.235294	235.192513		
Corrected Total	23	5233.958333			

R-Square	Coeff Var	Root MSE	sm Mean
0.011411	27.16337	15.33599	56.45833

Source	DF	Type I SS	Mean Square	F Value	Pr > F
type	1	59.72303922	59.72303922	0.25	0.6193

Source	DF	Type III SS	Mean Square	F Value	Pr > F
type	1	59.72303922	59.72303922	0.25	0.6193

Level of type	N	sm	
		Mean	Std Dev
coed	7	54.0000000	10.8320512
single	17	57.4705882	16.7149546

Bonferroni (Dunn) t Tests for sm

Note: This test controls the Type I experimentwise error rate, but it generally has a higher Type II error rate than REGWQ.

Alpha	0.05
Error Degrees of Freedom	22
Error Mean Square	235.1925
Critical Value of t	2.07387
Minimum Significant Difference	14.283
Harmonic Mean of Cell Sizes	9.916667

Note: Cell sizes are not equal.

Means with the same letter are not significantly different.			
Bon Grouping	**Mean**	**N**	**type**
A	57.471	17	single
A	54.000	7	coed

Scheffe's Test for sm

Note: This test controls the Type I experimentwise error rate.

Alpha	0.05
Error Degrees of Freedom	22
Error Mean Square	235.1925
Critical Value of F	4.30095
Minimum Significant Difference	14.283
Harmonic Mean of Cell Sizes	9.916667

Note: Cell sizes are not equal.

Means with the same letter are not significantly different.			
Scheffe Grouping	**Mean**	**N**	**type**
A	57.471	17	single
A	54.000	7	coed

Part 5 – Year 2003

The GLM Procedure

Class Level Information		
Class	**Levels**	**Values**
type	2	coed single

Number of Observations Read	364
Number of Observations Used	41

Dependent Variable: sm

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	665.048218	665.048218	3.82	0.0578
Error	39	6788.561538	174.065680		
Corrected Total	40	7453.609756			

R-Square	Coeff Var	Root MSE	sm Mean
0.089225	22.39872	13.19340	58.90244

Source	DF	Type I SS	Mean Square	F Value	Pr > F
type	1	665.0482176	665.0482176	3.82	0.0578

Source	DF	Type III SS	Mean Square	F Value	Pr > F
type	1	665.0482176	665.0482176	3.82	0.0578

Level of type	N	sm	
		Mean	Std Dev
coed	15	53.6000000	14.4805288
single	26	61.9615385	12.4144457

Bonferroni (Dunn) t Tests for sm

Note: This test controls the Type I experimentwise error rate, but it generally has a higher Type II error rate than REGWQ.

Alpha	0.05
Error Degrees of Freedom	39
Error Mean Square	174.0657
Critical Value of t	2.02269
Minimum Significant Difference	8.6526
Harmonic Mean of Cell Sizes	19.02439

Note: Cell sizes are not equal.

Means with the same letter are not significantly different.			
Bon Grouping	**Mean**	**N**	**type**
A	61.962	26	single
A	53.600	15	coed

Scheffe's Test for sm

Note: This test controls the Type I experimentwise error rate.

Alpha	0.05
Error Degrees of Freedom	39
Error Mean Square	174.0657
Critical Value of F	4.09128
Minimum Significant Difference	8.6526
Harmonic Mean of Cell Sizes	19.02439

Note: Cell sizes are not equal.

Means with the same letter are not significantly different.			
Scheffe Grouping	**Mean**	**N**	**type**
A	61.962	26	single
A	53.600	15	coed