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Gender differences in educational participation and achievement across subject areas

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Gender differences in educational participation and achievement across subject areas

During the last twenty years, female educational achievement has increased considerably in most Western countries, including New Zealand, Australia, the United Kingdom, and the United States (Gallagher 1998; Education Review Office 1999; Alton-Lee and Praat 2001; McNabb, Pal et al. 2002; Goldin, Katz et al. 2006; Gibb, Fergusson et al. 2008). This increase in achievement has been so dramatic that females now outperform males at all levels of the educational system, scoring higher on standardised tests of achievement and obtaining more educational qualifications at high school and in tertiary education. These trends have led many to conclude that females are no longer disadvantaged in educational achievement, and in fact, the disadvantaged gender group now appears to be males.

However, it is often claimed that within the general trend of female educational advantage there remain pockets of female educational disadvantage, particularly in mathematics and science (for example, see American Association of University Women Educational Foundation 1998; Greene, DeBacker et al. 1999; Van de Gaer, Pustjens et al. in press). Generally, it is proposed that this disadvantage is evident in two ways: in lower rates of female participation in mathematics and science education; and in low levels of female achievement in mathematics and science. Reduced female participation and achievement in mathematics and science are considered to be important because they may restrict later career opportunities and salary for women (see, for example, Greene, DeBacker et al. 1999; Watt 2005).

However, there is little evidential support for these claims. Evidence regarding gender differences in participation in mathematics and science is inconclusive, with some studies reporting female disadvantage (Turner and Bowen 1999; Cox, Leder et al. 2004), but others reporting no gender differences, or even a slight female advantage (Freeman 2004; Dalton, Ingels et al. 2007; Callister and Newell 2008). With regard to achievement, a 1990 meta-analysis concluded that there was a very slight and non-significant female advantage in mathematics achievement in general population samples (Hyde, Fennema et al. 1990), and the most recent round of the Trends in International Mathematics and Science Study (TIMSS) showed no significant gender difference in international average scores, although there was considerable variation between countries (Mullis, Martin et al. 2004). The recent TIMSS test of science achievement found a slight male advantage (Mullis, Martin et al. 2004), but the effect size for this gender difference was very small, a point emphasised in an earlier review of gender differences in science and mathematics achievement (Hyde and Linn 2006).

Against this background, this study examined gender differences in educational participation and achievement across a range of subjects, at high school and in tertiary education, in a New Zealand context. While there are factors other than gender that also influence educational achievement(such as ethnicity, social class, and others), the focus of this paper is on examining the extent of gender disadvantage in educational achievement. Data were drawn from the Christchurch Health and Development Study (CHDS), a cohort in which there is a substantial female advantage in general educational achievement (Fergusson and Horwood 1997; Gibb, Fergusson et al. 2008).

The specific aims of the study were:

i) To examine gender differences in participation across a range of subjects at School Certificate level

ii) To examine gender differences in achievement across a range of subjects at School Certificate level

iii) To examine gender differences in Bachelors degree attainment across a range of subject areas.

Methods

Sample and participants

The data used in this study were gathered as part of the Christchurch Health and Development Study (CHDS), a longitudinal study of a birth cohort of 1265 individuals born in Christchurch, New Zealand in 1977 and followed to age 30. The methodology and findings of the CHDS have been reviewed elsewhere (see Fergusson, Horwood et al. 1989; see Fergusson and Horwood 2001). Over the course of the study there has been a gradual loss of participants due to participant refusal, emigration from New Zealand, and death. The sample used in the current study consisted of 1050 of the original 1265 study participants, representing 83% of the original sample.

Outcome measures

School Certificate

When the CHDS cohort attended high school, students in Year 11 were eligible but not required to sit School Certificate examinations. At ages 18 and 21 participants were questioned about their history of achievement in School

Certificate examinations. Responses to these questions were used to determine the subjects and grades for each School Certificate subject sat by age 18. Subjects were classified into 14 categories: Accounting; Art; Science (including Biology, Physics, Chemistry, and General Science, although most students enrolled in General Science only); Economics; English; Geography; Foreign Languages (including French, German, Japanese, Latin and Spanish); History; Home Economics (including Food and Nutrition, and Clothing and Textiles); Mathematics; Music; Graphic Design; Typing; and Workshop Technology (including Woodwork and Metalwork). Where students sat more than one subject in a category, the grade for that subject category was the highest grade obtained for any subject within the category. A small number of students sat School Certificate subjects not included in the above list. These subjects were not considered in the analysis due to the small sample sizes.

Bachelors degrees

At ages 21, 25 and 30 participants were questioned about whether they had attained a Bachelors degree, and if so, the subject major for that degree. Responses to this question were used to categorise the degrees into 13 categories of subject major: Biological Sciences; Economics, Accounting and Business; Education; Engineering; English and languages; Fine and Performing Arts, Art History and Design; Health and Biological Sciences; Law; Physical Science, Computer Science and Mathematics; Social Sciences; and Other (for those not included in the above categories). Subject majors were not available for 38 participants (22 males, 16 females) and those participants were excluded from the degree analyses.

Gender

For the purposes of this paper, gender was the participant's sex as reported at the birth interview.

Statistical analyses

All statistical analyses were conducted using SAS 9.1 (SAS Institute 2003).

Differences between means were tested for statistical significance using a t-test for independent means, and differences between proportions were tested for statistical significance using a chi-square test for independence.

Effect sizes were calculated using the formula for Cohen's *d* (Cohen 1977) in which the difference between the means was divided by the standard deviation for the pooled sample.

Results

Table 1 shows the proportion of males and females in the sample who sat various School Certificate subjects. The table shows that there were gender differences in participation for some subjects. Females were significantly more likely than males to sit Science, English, Foreign languages, History, Home Economics, Music, and Typing (all $p<.03$), and marginally more likely to sit Art ($p<.07$). However, males were significantly more likely than females to sit Graphic Design and Workshop technology (both $p<.0001$), and marginally more likely to sit Accounting ($p<.06$). There were no significant gender differences for participation in Economics, Geography or Mathematics (all $p>.16$). The effect sizes for these gender differences in participation were small to medium. For those subjects in which females predominated, effect sizes ranged from .09 to .62 with a median value of .22, while for those subjects in which males predominated, effect sizes ranged from -.01 to -.49 with a median value of -.12.

INSERT TABLE 1 ABOUT HERE

The gender differences in subject participation reported in Table 1 raise questions about whether gender differences in achievement may also vary across different subjects. To examine this, Table 2 shows achievement in each School Certificate subject for males and females, measured in two ways: the success ratio (ratio of students passing to students sitting); and the mean grade (measured on a 5-point scale where 1=A grade and 5=E grade). The table shows a pervasive tendency for females to have higher achievement than males on both measures across almost all subjects. Overall, females had higher success ratios than males in 12 of the 14 subjects. The exceptions were Accounting, where males had slightly but not significantly higher success ratios, and Foreign Languages, where the gender difference in success ratios was negligible (both $p>.30$). The female advantage in success ratio was statistically significant for three subjects (English, History and Music, all $p<.02$), and marginally significant for another two subjects (Home Economics and Graphic Design, both $p<.10$). There were no subjects in which males had significantly higher success ratios than females. The effect sizes for the gender differences in success ratios ranged from small to large. For those subjects in which there was a female advantage in success ratio, effect sizes ranged from .07 to .80 with

a median value of .34. The effect sizes for the two subjects in which there was a male advantage in success ratio were small (-.03 and -.24).

The pervasive female advantage in educational achievement was also apparent in the mean grades. Females had higher mean grades than males in 12 of the 14 subjects. The exceptions were Economics and Mathematics, where the gender difference was negligible (both $p>.76$). The female advantage in mean grades was statistically significant for three of the subjects (English, History and Music, all $p<.01$). There were no subjects in which males had significantly higher mean grades than females. The effect sizes for the gender differences in mean grades ranged from small to large. For those subjects in which there was a female advantage in mean grades, effect sizes ranged from .10 to .82 with a median value of .39. The effect sizes for the two subjects in which there was a male advantage in mean grades were negligible (-.01 and -.02).

INSERT TABLE 2 ABOUT HERE

The findings presented in Tables 1 and 2 raise questions about whether gender differences in subject participation extend to tertiary education. Table 3 examines this issue. The table reports the proportion of males and females who completed Bachelors degrees with majors in various subjects. The table shows that, overall, women completed significantly more Bachelors degrees than men ($p<.002$). However, males and females tended to complete different subject majors for their Bachelors degrees. Females were significantly more likely than males to major in Education ($p<.006$), Health, Medicine and Biological Sciences ($p<.0004$), and Social Sciences ($p<.003$), and marginally more likely to major in English and Languages ($p<.06$). However, males were significantly more likely than females to major in Engineering ($p<.002$), and marginally more likely to major in Physical Science, Computer Science and Mathematics ($p<.07$). There were no significant gender differences for Accounting, Business and Economics; Fine and Performing Arts, Art History and Design; Law; or Other majors. The effect sizes for the gender differences were small. For those majors in which females predominated, effect sizes ranged from .03 to .23 with a median value of .12. For the three majors in which males predominated, effect sizes were -.20, -.12 and -.01.

INSERT TABLE 3 ABOUT HERE

Discussion

This paper examined gender differences in participation and achievement across a range of subject areas, at high school and in tertiary education. Overall, the results provided little support for claims that there remain some subject areas in which females are significantly disadvantaged compared to males.

At School Certificate level there were significant gender differences in participation in some subject areas, however the only subjects in which the gender differences were in the direction of female disadvantage were Graphic Design and Workshop Technology. Subject choice at Bachelors degree level was similarly gendered, with significant gender differences in the attainment of degrees in a number of subject areas. However, the only subject area in which females were significantly underrepresented was Engineering, with some indication of female under-representation also being evident in the area of Physical Science, Computer Science and Mathematics.

Despite these gender differences in participation, there was no evidence of female disadvantage in achievement in any School Certificate subject area. Instead, the results indicated a pervasive male disadvantage across almost all School Certificate subject areas.

These results do not provide support for strong claims that within the general trend of female educational advantage there remain pockets of substantial female disadvantage, particularly in mathematics and science. The results of the current study suggest that the trend of female advantage in achievement is apparent in all subject areas, and where female disadvantage in participation exists, the disadvantage is small and tends to occur in subjects associated with traditional male trades, such as Workshop Technology, Graphic Design, and Engineering, rather than in mathematics and science. At School Certificate level, male and female participation and achievement in mathematics were approximately equal, and in science, there were small female advantages in both participation and achievement. At Bachelors degree level, there was some indication that females were less likely than males to attain degrees in Physical Science, computer Science and Mathematics, but the gender difference was small and was only marginally significant.

It should be noted that, since the CHDS cohort attended high school, there have been substantial changes to the New Zealand secondary school qualifications system. It is therefore possible that patterns of male and female participation and achievement in the current qualifications system may differ from those observed in this study.

To place the gender differences reported in this paper in context it may be useful to consider their relationship to other determinants of achievement, such as ethnicity and social class. Social factors such as ethnicity and social class have substantial effects on educational achievement, which, in many cases, are larger than the effects of gender (for examples, see Gillborn and Mirza 2000; for examples, see Connolly 2006). However, there is a growing body of

evidence suggesting that the effects of gender on achievement are independent of the effects of ethnicity and social class, with each factor making a separate contribution to disadvantage (Demack, Drew et al. 2000; Gillborn and Mirza 2000; Coley 2001; Connolly 2006). It is therefore important to understand the ways in which each of these factors contributes to educational disadvantage.

The results of the current study revealed a small but pervasive female advantage in educational achievement that was evident at high school and in tertiary education, and extended across a wide range of subject areas. This finding provided little evidence for any remaining female disadvantage in education, but rather, suggested that the more significant gender issue in the New Zealand education system is the pervasive underachievement of males.

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Table 1. Proportion of males and females who sat various School Certificate subjects by age 18.

	Percent sitting subject			
	Males (N=520)	**Females (N=530)**	**p**	**d**
Accounting	11.5	8.0	<.06	-.12
Art	8.0	11.5	<.07	.12
Economics	24.3	22.1	.39	-.05
English	78.0	86.5	<.0005	.22
Foreign languages	7.6	25.6	<.0001	.48
Geography	28.5	28.1	.90	-.01
Graphic design	16.0	3.6	<.0001	-.42
History	15.2	24.3	<.0005	.23
Home Economics	3.9	14.2	<.0001	.36
Mathematics	77.0	80.5	.17	.09
Music	2.9	5.7	<.03	.14
Science	70.1	76.5	<.03	.15
Typing	1.9	22.0	<.0001	.62
Workshop technology	12.8	0.6	<.0001	-.49

Table 2. Success ratio and mean grade for males and females in School Certificate examinations, by subject

	Success ratio				Mean grade			
	Males	**Females**	**p**	**d**	**Males**	**Females**	**p**	**d**
Accounting (N=101)	.78	.69	.31	-.24	2.81	2.59	.30	.21
Art (N=100)	.78	.87	.23	.24	2.78	2.45	.11	.33
Economics (N=242)	.80	.83	.60	.07	2.84	2.84	.97	-.01
English (N=840)	.66	.82	<.0001	.35	3.06	2.64	<.0001	.45
Foreign languages (N=171)	.87	.86	.86	-.03	2.47	2.27	.29	.20
Geography (N=295)	.72	.78	.27	.13	2.96	2.86	.38	.10
Graphic design (N=99)	.78	.95	.09	.44	2.74	2.37	.11	.40
History (N=200)	.67	.86	<.002	.47	3.04	2.48	<.0001	.55
Home Economics (N=83)	.60	.80	<.07	.47	3.30	3.04	.11	.40
Mathematics (N=804)	.70	.71	.63	.03	2.71	2.73	.77	-.02
Music (N=45)	.80	1.00	<.02	.80	2.53	1.7	<.01	.82
Science (N=702)	.74	.79	.10	.12	2.71	2.59	.14	.11
Typing (N=120)	.70	.83	.32	.33	3.1	2.8	.26	.37
Workshop technology (N=66)	.73	1.00	.30	.62	2.95	2.33	.25	.69

Table 3. Proportion of males and females who hold degrees with selected subject majors[†]

	Percent with major			
	Males (N=473)	**Females (N=504)**	**p**	**d**
Accounting, business and economics				
Accounting	0.42%	1.19%		
Economics	0.21%	0.20%		
Management	1.27%	1.19%		
Other	1.06%	1.19%		
TOTAL	2.54%	2.98%	.68	.03
Education	1.27%	4.17%	<.006	.18
Engineering	2.96%	0.40%	<.002	-.20
English and foreign languages				
English	1.06%	2.19%		
Other Languages	0.64%	1.19%		
TOTAL	1.48%	3.37%	<.06	.12
Fine and performing art, art history, and design				
Art History	0.00%	1.59%		
Design / Architecture	1.27%	1.19%		
Other	1.27%	1.39%		
TOTAL	2.54%	3.77%	.27	.07
Health, medicine, and biological sciences				
Medicine	0.42%	0.20%		
Nursing	0.00%	2.19%		
Biological Sciences	0.85%	1.39%		
Other	0.42%	2.19%		
TOTAL	1.48%	5.95%	<.0004	.23
Law	1.27%	2.58%	.14	.09
Physical science, computer science, and mathematics				
Chemistry	0.85%	0.40%		
Computer / Information Science	1.49%	0.40%		
Mathematics / Statistics	0.21%	0.60%		
Physics	0.21%	0.00%		
Geology	0.42%	0.00%		

TOTAL	3.17%	1.39%	<.07	-.12
Social sciences				
Classics	0.21%	1.19%		
Political science	0.42%	1.19%		
Psychology	0.85%	2.78%		
Sociology	0.42%	1.59%		
Other	2.55%	2.98%		
TOTAL	4.23%	9.13%	<.003	.20
Other				
Physical Education	0.42%	0.60%		
Resource Studies	1.27%	0.80%		
Other	1.06%	1.19%		
TOTAL	2.75%	2.58%	.87	-.01
Total number of Bachelors degrees	113	175	<.002	.21

† Note: Some participants completed degrees with double majors, therefore the total number of subject majors exceeds the total number of Bachelors degrees recorded in the table.

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