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Regional and Gender Differences in Mathematics Achievement

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This study investigated the participation and performance of country and metropolitan students in mathematics subjects taken to complete the Victorian Certificate of Education (VCE), the secondary education qualification through the state of Victoria, Australia. The direction of gender differences varied with the particular assessment administered. Further, there was a significant regional effect where country students—particularly males—tended to perform less well than their metropolitan counterparts.

The study of gender differences in senior secondary school mathematics achievement has been explored in great detail, with results generally indicating that males perform better than females on external examinations (Lydeamore, 1993; MacCann, 1995; Stobart, Elwood, & Quinlan, 1992; Whitehouse & Sullivan, 1992; Willis, 1989) and assessments comprising multiple-choice items (Sharma & Meighan, 1980; Stobart et al., 1992; Whitehouse & Sullivan, 1992; Willis, 1989). However, school-based assessment and course-work components of mathematics assessment have been shown to favour females (Kimball, 1989; Lydeamore, 1993; MacCann, 1995; Parker in Rennie & Parker, 1991; Stobart et al., 1992; Whitehouse & Sullivan, 1992).

The location of schools appears to affect male and female performance, with studies in Canada suggesting that country females are less disadvantaged in mathematics performance than their city counterparts, perhaps because in urban communities there may be more rigid sex role differentiation (Randhawa, 1988; Randhawa & Hunt, 1987). These researchers also found that students from rural classrooms achieved better on mathematical concepts than those from urban classrooms. In contrast, Methen and Wilkinson (1988), who studied Year 12 students in Kuwait, found that males in rural schools did no better than their urban counterparts in mathematics, but that the females in urban schools outperformed their rural counterparts. Teese, Charlton, and Polesel (1994) found lower participation rates, lower transition rates to Year 12, and poorer performance in lower socioeconomic regions of Melbourne (Australia) and in country Victoria (also see Ethington, 1990).

Teese, Davies, Charlton, and Polesel (1995) found that the mathematics performance of country students was lower than that of most urban students. Further, in the country and higher socioeconomic status suburbs (but not in the intermediate socioeconomic status suburbs), females outperformed their male counterparts. Gilbert (1995) also reported that Years 3, 7, and 10 Western Australian students from metropolitan schools outperformed rural students in mathematics.

Teese et al. (1995) and Whitehouse and Sullivan (1992) found that large and significant locational differences, disfavouring country candidates, were present in Year 12 examination results for mathematics and all science subjects. Whitehouse and Sullivan (1992) suggested that an inequality of opportunity for country students was caused by such factors as limited resources and subject choices, less experienced teachers, and less adequate in-service teacher education in country schools.

The Victorian Certificate of Education

In 1992, when the new Victorian Certificate of Education (VCE) was fully introduced at Years 11 and 12 in the state of Victoria (Australia), new mathematics subjects and forms of assessment were in place. The underlying philosophy behind the changes to mathematics was to create a course that catered to the needs and aspirations of all students by using a variety of teaching and assessment strategies (Blackburn, 1985). This philosophy came from a national review of postcompulsory schooling known as the Blackburn Report (Blackburn, 1985), which forced this major curriculum innovation in response to the increasing participation rates in postcompulsory education and changes to work in the post-industrial era.

The VCE provided the opportunity to study male and female participation and performance in Year 12 mathematics. There were six distinct Year 12 mathematics subjects in the VCE: space and number (S&N), extensions space and number (S&N-E), change and approximation (C&A), extensions change and approximation (C&A-E), reasoning and data (R&D), and extensions reasoning and data (R&D-E). "Extensions" subjects were designed for students who had already studied the subject in Year 11.

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Table 1
Number and Percentage of Females and Males Assessed for CAT 1 for Each of the Six Mathematics Subjects

	CAT 1			
Subject	*N*(F)	*N*(M)	%(F)	%(M)
S&N	3558	3623	12.6	15.0
S&N-E	2351	2302	8.3	9.5
C&A	3349	2605	11.9	10.8
C&A-E	4009	6376	14.2	26.4
R&D	6079	7576	21.6	31.4
R&D-E	67	85	0.2	0.4

Note. Percentages do not sum to 100% because students taking two or more subjects are counted more than once.

In each of the six Year 12 mathematics subjects, all students in Victoria were assessed identically using four externally set Common Assessment Tasks (CATs; Victorian Curriculum and Assessment Board, 1990). The first two CATs were internally assessed (assessed at the school level, followed by a statewide process of verification to ensure comparability of marking across schools) and were performed over an extended period of time. CAT 1, "Investigative Project," was a 1500 word written report based on an independent mathematical investigation. For CAT 2, "Challenging Problem," the student selected one of four set problems and used a number of problem solving strategies and/or modelling to prepare a report including a solution. The last two CATs were in the traditional examination style. CAT 3, "Facts and Skills Task," comprised 49 multiple-choice questions. CAT 4, "Analysis Task," contained 4-6 short-answer questions that required solutions of increasing complexity. Student performance on all CATs was reported using eleven letter grades, descending from A+ to E and UG (ungraded); an E was considered a basic pass.

Method

The purpose of this study was to examine the relative mathematics performance, at Year 12, of males and females and any regional (country versus metropolitan) differences. Performance and participation in mathematics are linked. The 1992 VCE Year 12 mathematics students are considered here to be a representative sample of a much larger population of Year 12 mathematics students across many years. The 1992 database contained records of 45,206 students who had enrolled in at least one VCE Year 12 mathematics subject.

The 11-point grading scale (A+, A, ... , E, UG) was converted to a score out of 10 (i.e. A+ = 10, A = 9, . . . , UG = 0). Students were classified according to gender and the region in which their school was located (Melbourne metropolitan regions versus the country regions). Multiple MANOVA tests were carried out for each of the six VCE mathematics subjects; a conservative estimate of the adjusted alpha value was made using a Bonferroni adjustment. Unequal cell sizes were not equalised; however, the *SPSS* MANOVA program adjusted for the unequal cell sizes in calculations using the sequential approach (Tabachnick & Fidell, 1989, p. 404).

Results

Do Males Differ from Females with Respect to Mean Performance on CATs 1 to 4?

Participation of males and females in VCE mathematics. The numbers of students enrolled in each of the six mathematics subjects are presented in Table 1. For simplicity, only CAT 1 values are provided as the other three CATs had almost identical values. The R&D-E numbers are extremely low because very few schools offered this subject in their curricula. It can be seen that, generally, there was a higher proportion of males doing all mathematics subjects at VCE in 1992 except for C&A. The small female advantage in C&A is overshadowed by the more demanding C&A-E, in which the percentage enrolment is considerably more for males than for females.

Gender differences in performance on the CATs. Table 2 presents mean scores, by sex, for each CAT. Standard deviations ranged from 2.1 to 2.8; Box's *M* test indicated no significant difference between the variances for all possible comparisons.

A one-factor (sex) MANOVA, for each mathematics subject, resulted in a significant effect of sex ($p < .05$) in all six subjects. The subsequent univariate tests displayed significant differences in many of the CATs. Females were significantly higher in four of the subjects for CAT 1 (S&N-E, C&A, C&A-E, R&D), three of the subjects for CAT 2 (S&N-E, C&A-E, R&D), and one subject for CAT 3 (S&N-E). Males were significantly higher in four of the subjects for CAT 3 (S&N, C&A, C&A-E, R&D), and three subjects for CAT 4 (S&N, C&A-E, R&D).

Do Males Differ from Females in Mathematics Performance when the Location (Country Versus Metropolitan) of their Schools is Taken into Account?

Participation of country and metropolitan males and females in VCE mathematics subjects. The number of female and male students in the country and metropolitan regions enrolled for CAT 1, and the female, male, and combined female and male percentages of their respective country or metropolitan population are summarised in Table 3

Table 2
Means, by Sex and CAT, for Each of the Six Mathematics Subjects

	CAT 1		CAT 2		CAT 3		CAT 4	
Subject	F	M	F	M	F	M	F	M
S&N	4.82	4.61	5.32	5.35	5.05	5.63	3.97	4.94
S&N-E	4.36	3.52	4.89	4.15	2.93	2.65	3.20	3.07
C&A	6.35	5.92	6.54	6.38	5.29	5.55	6.13	6.25
C&A-E	6.73	6.17	6.79	6.65	5.76	5.95	5.61	6.09
R&D	5.51	5.20	5.96	5.99	5.72	6.09	4.49	5.07
R&D-E	5.84	5.18	6.60	5.65	3.22	3.19	4.63	5.18

Table 3
Number and Percentage of Females and Males Assessed for CAT 1 for Each of the Six Mathematics Subjects, by Region

	N (country)		*N* (metro)		% (of country)			% (of metro)		
Subject	F	M	F	M	F	M	ALL	F	M	ALL
S&N	945	758	2612	2863	12.4	12.2	12.3	12.6	15.9	14.2
S&N-E	708	681	1643	1621	9.4	10.9	10.0	8.0	9.1	8.5
C&A	631	454	2718	2151	8.3	7.3	7.9	13.1	12.0	12.6
C&A-E	964	1458	3044	4915	12.7	23.4	17.5	14.7	27.4	20.6
R&D	1777	2223	4301	5351	23.4	35.7	29.0	20.8	29.8	25.0
R&D-E	17	16	50	69	0.2	0.3	0.2	0.2	0.4	0.3
OVERALL					59.2	70.6	64.4	61.0	72.4	66.3

Table 4
Mean Scores for Country (C) and Metropolitan (M) Students in All CATs for All Subjects

	CAT 1		CAT 2		CAT 3		CAT 4	
Subject	C	M	C	M	C	M	C	M
S&N	4.31	4.84	4.88	5.47	4.97	5.46	4.27	4.51
S&N-E	3.95	3.94	4.69	4.46	2.76	2.81	3.34	3.05
C&A	5.88	6.23	6.35	6.50	5.14	5.46	5.99	6.23
C&A-E	6.12	6.47	6.48	6.77	5.56	5.97	5.90	5.91
R&D	5.32	5.34	5.89	6.01	5.94	5.92	5.01	4.73
R&D-E	5.88	5.35	5.94	6.11	2.84	3.30	4.50	5.05

Table 5
Nonquantitative Summary of Significant Univariate Tests for Region Effects on Mathematics Achievement

Subject	CAT 1	CAT 2	CAT 3	CAT 4
S&N	metro	metro	metro	
S&N-E				country
C&A	metro		metro	metro
C&A-E	metro	metro	metro	
R&D		metro		country

There were many more VCE students in the Melbourne metropolitan area (20,640 females and 17,908 males) compared to the country regions (7,564 females and 6,212 males) (Victorian Board of Studies, personal facsimile communication from I. Sulcs, January 4, 1996). There were larger percentages of country students studying S&N-E and R&D. However, there were larger percentages of metropolitan students studying the remaining four subjects.

Regional Differences in mathematics performance. Mean scores appear in Table 4. Standard deviations ranged from 2.0 to 2.8; Box's *M* test indicated no significant difference between the variances for any of the country and metropolitan data.

A one-factor (region) MANOVA, for each mathematics subject, resulted in a significant effect of region ($p <$ .05) for five of the six tests. The results of the subsequent univariate tests are summarised, nonquantitatively, in Table 5.

Intra-regional performance differences between males and females in country and metropolitan schools. Table 6 reports the mean female and male scores for each of the CATs, by region.

The MANOVA results on intra-regional gender differences were significant for all mathematics subjects except R&D-E. The results of the subsequent univariate tests for the sex effect, by region, are summarised in Table 7.

Inter-regional performance differences between males and females in country and metropolitan schools. To consider whether metropolitan and country differences are evenly distributed amongst male and female students, the differences between country and metropolitan students were calculated by gender. The differences were calculated by subtracting the average metropolitan CAT score for females or males from the average country CAT score for females or males. The results of this calculation are presented in Table 8.

Roughly two thirds (33/48, or 69%) of the differences in Table 8 favour metropolitan students, pointing to a possible advantage for these students over their country counterparts. A multivariate test of the two-way interaction of region by sex resulted in statistical significance for four subjects: Three on CAT 1 (S&N, S&N-E, C&A) and one on CAT 2 (S&N).

Table 6
Means, by Sex and Region

	CAT 1		CAT 2		CAT 3		CAT 4	
Subject	F	M	F	M	F	M	F	M
				Metro				
S&N	4.89	4.80	5.40	5.54	5.13	5.76	3.99	5.00
S&N-E	4.30	3.57	4.83	4.08	2.97	2.64	3.17	2.93
C&A	6.38	6.03	6.56	6.42	5.34	5.62	6.18	6.29
C&A-E	6.80	6.27	6.86	6.71	5.88	6.04	5.62	6.08
R&D	5.50	5.21	5.95	6.06	5.71	6.09	4.42	4.99
R&D-E	5.40	5.32	6.56	5.78	3.21	3.37	4.72	5.29
				Country				
S&N	4.64	3.91	5.09	4.63	4.83	5.15	3.92	4.72
S&N-E	4.48	3.40	5.04	4.31	2.84	2.67	3.28	3.41
C&A	6.21	5.42	6.47	6.19	5.09	5.21	5.94	6.06
C&A-E	6.52	5.84	6.57	6.42	5.37	5.68	5.58	6.11
R&D	5.55	5.15	5.99	5.82	5.77	6.08	4.68	5.27
R&D-E	7.12	4.56	6.71	5.13	3.24	2.40	4.35	4.67

Table 7
Summary of the Number of Univariate Results Significantly Favouring Females and Males, by Region and Overall

	CAT 1	CAT 2	CAT 3	CAT 4
Country	5/6 F	2/6 F	3/6 M	3/6 M
Metropolitan	4/6 F	1/6 F, 2/6 M	1/6 F, 4/6 M	3/6 M
Overall	4/6 F	3/6 F	1/6 F, 4/6 M	3/6 M

Note. "4/6 F" means that four of the six subjects had a significant (adjusted $p < .05$) sex effect on achievement in favour of females.

Separate MANOVA tests were run for males and for females to further assess regional differences. Results were significant (adjusted $p < .01$) for males in all subjects except R&D-E, and for females in all subjects except R&D-E and C&A. The results of the subsequent univariate tests are summarised in Table 9.

Discussion

Do Males Differ from Females with Respect to Mean Performance on CATs 1 to 4?

Females generally outperformed males on CATs 1 and 2, while males generally outperformed females on CATs 3 and 4. Also, females, relative to males, performed more poorly as one progressed from CAT 1 to CAT 4. Each of these four CATs contributed equally to a student's final grade and tertiary entrance score. There was no intended, or perceived, progression of difficulty through these four tasks. CAT 2 results showed females significantly outperforming males in three of the six subjects. Both CATs 1 and 2 involve significant amounts of written work to be done over an extended period. Drafts of work can be submitted to teachers and the final product constitutes a written report. Females, on average, would appear to be more capable than the males in this area, possibly due to their good communication skills, their ability to apply themselves to an extended task, and their conscientiousness and preparedness to seek help with drafts more frequently than males (e.g., Rowley, Leder, & Brew, 1994). The finding of females performing better in school-based styles of assessment is consistent with results obtained by others (e.g., Lydeamore, 1993; MacCann, 1995; Parker, in Rennie & Parker, 1991; Stobart et al., 1992; Whitehouse & Sullivan, 1992).

In CAT 3, males performed significantly better than females in four of the six subjects. Females perform significantly better than males in S&N-E. Reviews by Sharma and Meighan (1980), Stobart et al. (1992), Whitehouse and Sullivan (1992), and Willis (1989) indicated that males consistently do better than females on multiple-choice items, and that this is not changing over time. Stobart et al. (1992) suggested that a factor in the males' favour may be that they do not have to express themselves in English. This conjecture also is consistent with the relatively better performance of females in CATs 1 and 2.

CAT 4 results, though less strongly than CAT 3 results, still show males in three of the six subjects significantly outperforming females. Findings for CAT 3 and CAT 4 add to the considerable body of evidence already existing that in Australia gender differences in mathematics achievement at the age of 17 consistently favour males (Adams, 1985; Atkins, Leder, O'Halloran, Pollard, & Taylor, 1991; Daley, 1985; MacCann, 1995). Findings for CATs 1 and 2, however, challenge earlier findings and add to the growing evidence (Lydeamore, 1993; MacCann, 1995; Parker in Rennie & Parker, 1991; Stobart et al., 1992; Whitehouse & Sullivan, 1992) that the use of school-assessed components in senior secondary mathematics tends to favour females.

Do Males Differ from Females in Mathematics Performance when the Location (Country Versus Metropolitan) of their Schools is Taken into Account?

Participation of country and metropolitan males and females in VCE mathematics subjects. Metropolitan females and males outnumbered their country counterparts in VCE Year 12 subjects by a ratio of three to one; and as one would expect, there was a similar ratio in the mathematics enrolments of country and metropolitan students. In terms of percentages, however, more metropolitan than country students enrolled in four of the six mathematics subjects. The two major calculus subjects, C&A and C&A-E, were amongst these four subjects. This finding is consistent with the work of Teese et al. (1994), who found that the lower participation rate of country students in mathematics was most pronounced in the more demanding subjects. Proportions of students participating did not range markedly by gender between country and metropolitan regions.

Regional Differences in mathematics performance. Country students performed significantly better than their metropolitan counterparts in only 2 of the 24 possible CATs. In contrast, metropolitan students performed significantly

Table 8
Differences Between the Mean Country and Metropolitan Scores for All Subjects, by Gender

	CAT 1		CAT 2		CAT 3		CAT 4	
	F	M	F	M	F	M	F	M
S&N	-0.25	-0.89	-0.31	-0.91	-0.3	-0.61	-0.07	-0.28
S&N-E	0.18	-0.17	0.21	0.23	-0.13	0.03	0.11	0.48
C&A	-0.17	-0.61	-0.09	-0.23	-0.25	-0.41	-0.24	-0.23
C&A-E	-0.28	-0.43	-0.29	-0.29	-0.51	-0.36	-0.04	0.03
R&D	0.05	-0.06	0.04	-0.24	0.06	-0.01	0.26	0.28
R&D-E	1.72	-0.76	0.15	-0.65	0.03	-0.97	-0.37	-0.62

Note. Positive values represent country students performing better.

better than their country counterparts in 10 of the 24 possible CATs. These findings are consistent with analyses of other Australian mathematics and science examination results, which report lower performance levels for country students (e.g., Teese et al., 1995; Whitehouse & Sullivan, 1992). Whitehouse and Sullivan (1992) suggest that comparative inequality of opportunity for country students accounts for the lower achievement of country students. This alternative explanation was a criticism, made by country teachers, of the first two mathematics CATs in the VCE. They argued that country students were disadvantaged, compared with their metropolitan peers, by a lack of resourcing, networks, and training-in-place in the country to assist teachers in coping with such forms of assessment. This argument has merit in the case of the present findings, since the major proportion of the significantly better metropolitan performance appears in results for the first three CATs. Only in CAT 4, the traditional style of examination, did the country students perform significantly better than their metropolitan peers.

Intra-regional performance differences between males and females in country and metropolitan schools. Country females generally performed better than country males on CAT 1 and CAT 2 than their metropolitan counterparts. This evidence is weak, however, and intra-regional gender differences in performance generally follow the pattern of differences observed in the overall state population.

Inter-regional performance differences between males and females in country and metropolitan schools. The calculated differences between country and metropolitan males and females pointed to a possible advantage for metropolitan students, with 69% of the differences favouring metropolitan students. MANOVA tests were run separately for males and females. From these tests, it appeared that metropolitan females performed significantly better than country females in five instances for CATs 1 to 3, and country females performed significantly better than metropolitan females in one instance in CAT 4. Three of the five significant metropolitan female performances occurred in C&A-E, the most demanding mathematics subject. The same tests for males showed that metropolitan males performed significantly better than country males in nine instances for CATs 1 to 3, and country males performed significantly better than metropolitan males in two instances in CAT 4. These findings corroborate a finding that country males do less well than country females when compared to their metropolitan counterparts. Again, the comparatively better country performance on CAT 4 may indicate an unequal opportunity to prepare for nontraditional assessment styles (possibly represented by CATs 1 to 3). These findings add further weight to the preceding finding that the style of assessment used on CATs 1 to 3 in 1992 appears to have favoured the metropolitan students, and that the traditional examination style of CAT 4 was the only style of assessment that lacked a regional inequality of opportunity.

Conclusions and Recommendations

The study of differential performance cannot be viewed without an understanding of underlying participation differences. This study has identified groups of mathematics students who participate more or less in mathematics subjects and perform better or worse with variations associated with varying styles of assessment.

Statistical tests on large populations have been employed in this study, and as Walkerdine (1989, p. 14) warns "in large surveys trivially small differences may be highly significant statistically, and this significance may be deceptive." The statistical significance of these findings needs to be related to educational significance. The size of the differences reported, and the conservative estimates used

Table 9
Summary of the Number of Univariate Results Significantly Favouring Country and Metropolitan Students, By Sex and Overall

	CAT 1	CAT 2	CAT 3	CAT 4
Female	1/6 M	2/6 M	2/6 M	1/6 C
Male	3/6 M	3/6 M	3/6 M	2/6 C
Overall	3/6 M	3/6 M	3/6 M	2/6 C, 1/6 M

Note. "3/6 M" means that three of the six subjects had a significant (adjusted $p < .05$) sex effect on achievement in favour of metropolitan students.

in significance testing, point to educationally meaningful differences where statistically significant differences were obtained.

The findings from this study indicate that females are not so disadvantaged in VCE mathematics assessment as they have been in earlier mathematics courses in Victoria. The largest disadvantage occurs for females in terms of participation, particularly in double-mathematics courses and advanced mathematics subjects. This study has shown, as have Rowley et al. (1994) and Teese at al. (1995), that females performed significantly better than males in most subjects on CATs 1 and 2, while males performed significantly better than females in more subjects on CATs 3 and 4. The different forms of assessment known as internally assessed CATs and test CATs appear to measure different mathematical skills. This innovation in mathematics assessment in the VCE appears problematic since CAT 2 was removed for verification reasons in 1993.

Consistent with the findings of Teese et al. (1994, 1995), the present study finds country students to be disadvantaged compared with metropolitan students, a disadvantage occurring mainly in CATs 1, 2 and 3, and more particularly for country males. It is also possible that differential selection of mathematics courses may account for some of the observed differences. However, as country students performed relatively better on CAT 4, some other effect may be operating. The inequality of opportunity proposed by Whitehouse and Sullivan (1992) for country students is a plausible contributor to results reported here for CATs 1, 2 and 3. The regional performance differences found for the newer forms of assessment may have been caused by more limited access to resources and training for teachers in country schools.

Male students are perhaps becoming the new underclass in Australian schools as Messina (1995) charges and it could be argued that this study develops evidence to support such a view. The under-enrolment of females in mathematics, particularly in advanced mathematics courses, is a well-recognized problem. However, over-enrolment by males in mathematics is an equal, if seldom recognized, problem, and less capable males pay the price in the form of lower grades. Misguided assumptions about the future cause males (as well as females) to make course choices potentially harmful to their postsecondary prospects.

Techniques need to be researched and developed to help males improve their written communication skills and to help both males and females select more appropriate subjects in Year 12. Initiatives are in place to assist females, and these initiatives need to be further developed, particularly to find ways to encourage females to take the more specialised mathematics subjects.

Finally, the possible disadvantage for country students in CATs 1, 2 and 3 needs to be more fully investigated to determine the persistence of the effect reported here. If such an effect is found, then regional training and resourcing initiatives need to be developed to overcome such imbalances. Resourcing and training may be able to bring teachers and students from the country and city closer together. Tools currently being introduced to all Victorian schools, particularly telecommunications, may prove effective.

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