DO GIFTED BOYS PERFORM BETTER IN MATHEMATICS THAN GIFTED GIRLS?

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DO GIFTED BOYS PERFORM BETTER IN MATHEMATICS THAN GIFTED GIRLS?[1]

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ABSTRACT

This paper focused on the gender differences in mathematical performance in gifted secondary students in three single-sex secondary schools. It considered the performance in elementary and additional mathematics of eight cohorts of students across Secondary One to Four in the Gifted Education Programme. The sample was made up of 1410 girls and 2454 boys. A subsample of 364 Secondary 3 and 4 students also sat for the SAT-M test. No gender differences were found in the school-based examinations. However, there were gender differences favouring girls in SAT-M; a finding in contrast to most studies. The strengths of the girls lied in content areas such as arithmetic and geometry. The paper also looked at the implications of these findings for the gifted programme.

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INTRODUCTION

The purpose of this study is to investigate whether gender differences existed in mathematics performance between male and female secondary gifted students in Singapore. The topic of gender differences in mathematical ability and achievement has been the interest of many researchers as far back as the 1970's. Maccoby and Jacklin (1974) reviewed and summarised a vast array of gender studies. They concluded that males had better mathematical ability and visual-spatial ability than females. However, later research studies by Feingold (1988), Friedman (1989), and Hyde, Fennema and Lamon (1990) produced a complete spectrum of conclusions, ranging from male superiority, no differences, to female excellence.

Some studies such as Armstromg (1985) found that gender differences in mathematics vary with item types and content areas. He found that girls were better at computation and spatial visualisation than boys. Rosser (1989) found that scores on standardised tests tend to under-predict girls' mathematics academic performance in the classroom. Other studies found that gender differences increase substantially in favour of males with the onset of adolescence (Weiner & Robinson, 1986; Hyde, Fennema & Lamon, 1990). Studies on younger children reported that girls obtained higher mathematics scores than boys (Marshall & Smith, 1987) and local mathematics studies on 16-year olds indicated gender differences in favour of the boys (Kaur, 1987; Tan, 1990).

Gender-related differences in favour of males appear to be more pronounced in academically talented populations (Benbow, 1988; Swiatek & Benbow, 1991, Benbow, 1992). Their work was mainly on the *mathematically* able twelve-year-old students in the US identified through the Mathematics Talent Search for the Study of Mathematically Precocious Youth (SMPY). The instrument used was the Scholastic Aptitude Test (SAT). Their longitudinal follow-up studies on these precocious youths from junior high to high school reported consistent gender differences among several cohorts of students.

In the present study, gender differences among the gifted secondary students in Singapore were assessed and patterns of such differences explored. Trends in mathematics performance were studied among students across Secondary 1 (Grade 7) to Secondary 4 (Grade 10) using school-based examination scores. A subsample consisting of only Secondary 3 (Grade 9) and 4 (Grade 10) students was used for the second half of the study to further investigate the nature of gender differences in mathematics achievement using the Scholastic Aptitude Test-Mathematics (SAT-M). The achievement of the local gifted students was later used to compare with that of the American gifted students.

METHOD

Sample

The sample was drawn from participants in a school-based Gifted Education Programme (GEP) in 3 single-sex secondary schools. The 3864 students (1410 girls and 2454 boys) from 8 cohorts were 12 to 16 years of age. A sub-sample of 377 upper secondary students (142 girls and 220 boys) was selected to take the SAT-M.

Instruments

Mathematics achievement in classroom content-specific tests was measured by scores obtained at the GEP School-based Examinations in Elementary Mathematics and Additional Mathematics. These examinations, administered twice yearly at Secondary 1 through Secondary 3, were differentiated from the main stream as they were pitched at a more difficult level. They aimed to test the students' level of competency, understanding and application skills in the concepts taught during lessons, with about 40% of the items on higher mathematical reasoning in analysis and synthesis. At secondary 4, the GEP students are examined by their schools.

The College Board's Scholastic Aptitude Test (SAT-M) was selected as the standardised test. The SAT-M is developed by Educational Testing Service in Princeton, New Jersey for 16- to 18-year olds to measure developed mathematical reasoning ability. The SAT-M consists of 40 standard multiple-choice items on arithmetic, algebra, geometry and miscellaneous areas as well as 20 quantitative comparison questions, all to be solved within 60 minutes. Quantitative comparison items require the candidate to examine 2 given sets of data and to decide whether one is equal to, greater than or less than the other quantity. There is no necessity to work out the actual numerical solutions to these comparison items. Other questions in the SAT-M require the application of numerical, graphical, spatial symbolic and logical techniques to familiar situations. The SAT-M questions were sorted for investigation on the basis of their item format (Multiple-Choice Questions & Quantitative Comparison Items), content-area (Algebra, Arithmetic, Geometry and Miscellaneous), the requirement of spatial ability (Presence of a Diagram) and response omission rate.

ANALYSIS AND FINDINGS

Standardised scores of School-Based Examinations

The raw scores obtained on the school examinations were standardised because these examinations were not the same for each year. The data were standardised to have a mean of 50 and a standard deviation of 10. Mean marks were obtained for each level of the sample. Table 1 contains the summary statistics, the effect size of the differences and the results of the two-tail t-tests. Negative effect size indicates that the males' mean score is larger than the females. Although the boys obtained higher mean scores than the girls in Sec 1, 3 and 4, there were no significant gender differences detected at any of the 4 levels in both Elementary and Additional Mathematics. Using Cohen's distinction (1969) of 0.20 in absolute value as a small effect size, 0.50 as a medium, and 0.80 as large, the effect sizes displayed in Table 1 confirm with the t-test values that there were no gender differences in the students' performances on school examinations. The girls were equally as proficient in their school examinations as the boys throughout the 4 years at secondary school.

Insert Table 1 here

In order to tease out possible patterns in gender differences, the data were regrouped using 4 different procedures. First, examinations results were classified by Semester (Semester I & Semester II) and by the 4 levels (S1, S2, S3, S4). Secondly, examinations were divided into only either *Semestral I* or *Semestral II* examinations. The third category separated the examinations as either from the lower (*Lower Sec*) or the upper (*Upper Sec*) secondary levels. Finally, the results from all examinations were pooled together into a single mean score (*Total*). The data were reexamined. Table 2 displays the descriptive statistics and t-tests of the various examinations within each category.

Insert Table 2 here

Under *Semester I* in Table 2 , while the girls obtained higher scores at Sec 1 and Sec 2 (EM S1 & EM S2) in Elementary Mathematics, the boys outperformed the girls at Sec 3 (EM S3). There were no gender differences in Additional Mathematics at Sec 3 (AM S3). Although the boys obtained higher scores on *Semestral II* examinations (EM S1,EM S2,EM S3 & AM S4), however, only at Sec 1 for Elementary Mathematics was the differential performance between the 2 genders statistically significant. The effect size for Sec 2 and Sec 3 students in the Semester I examinations were 0.21 and 0.32 respectively. The gender differences registered significance by the two-tail t-tests were considered small.

Taking all the Semestral I examinations as a whole, girls and boys performed equally well in all the Semestral I examinations. Table 2 shows t-value as -0.62. On the other hand, there was significant (t-value = 2.54) gender differences in the scores obtained at the Semester II examinations. On average, the boys obtained significantly higher scores than the girls at these examinations.

No significant t-values were located in each of the summary figures under *Lower Sec*, *Upper Sec* and *Total* in Table 2. At the lower secondary level as well as at the upper secondary level, there were no gender differences. These separate findings were consistent with results from of the testing of gender differences on the mean score (*Total*) computed from the pooled data on examination results. In conclusion, no gender differences were found in school-based examinations performance.

Raw Scores of the SAT-M

The SAT-M test was marked against the given answer key. Table 3 gives the summary statistics and two-tailed t-values. Generally, the mean number of correct responses (*SAT*) from the female sample was higher than that of the male sample. There was greater variability in the boys' scores. The t-test comparisons of these means indicated strong significant differences favouring the girls for all categories except for multiple-choice questions (*MCQ*) and algebra items (*Algebra*). However, the effect sizes, ranging between 0.18 and 0.35 for the significant categories, indicated the gender differences were small in magnitude in relation to the sample size.

Insert Table 3 here

Details in Table 3 showed that the girls did better than the boys in the quantitative comparison items (*Quan*). However, the differences found in quantitative comparison items were small, as indicated by the effect size of 0.354. In particular, the girls' strengths were in Arithmetic, Geometry and in items accompanied by figures and diagrams (*Figure*). In none of the subcategories, were the boys' performance superior to that of the girls'. In the Miscellaneous category where the items were not directly related to topics taught in the classroom, there were significant gender differences at the 0.025 level.

Pearson correlations between the students' SAT-M scores and school examinations results showed that SAT-M scores were moderately correlated to achievement in school based examinations ($r = 0.35$, $p < 0.0001$). School examination performance was able to account for 12% ($r^2 = 0.12$) of the variance in SAT-M scores.

Insert Table 4 here

The SAT-M was more strongly correlated to school examinations for the girls ($r = 0.53$, $p<0.0001$) than for the boys ($r = 0.298$, $p<0.0001$). The SAT-M scores explained 28% ($r^2 = 0.27$) of the girls' variation in school performance compared with 9% ($r^2=0.09$) of the boys'.

Standardised SAT-M Scores

The College Board reported standardised SAT scores, corrected for guessing. Table 5 shows the SAT scores, standardised and corrected for guessing, in line with that reported by the College Board. The GEP girls scored a mean standard score of 676 points compared to the boys' mean score of 648. The two-tailed t-test comparisons of mean SAT-M scores indicated significant differences between the boys and girls. The advantage of the girls was still evident in the section containing quantitative comparison items (*Quan*) where the girls obtained higher scores than the boys. No gender differences were found in the MCQ items.

Insert Table 5 here

The corresponding mean scores for high school girls and boys from Benbow and Minor's (1986) longitudinal study were 650 and 695. Table 6 shows the details for earlier years (Benbow & Stanley, 1982). While the Singapore boys registered a lower mean SAT-M score than their American counterparts, the local girls scored higher than the American girls. The Singapore experience indicated a different gender trend in mathematics achievement among the gifted and talented.

Insert Table 6 here

In summary, there were gender differences favouring the girls on items from all the respective content areas (Arithmetic, Geometry and Miscellaneous) except in Algebra. The girls were better in the MCQ format rather than quantitative comparisons. These findings affirmed the direction of gender differences found in the SAT-M score: the girls obtained significantly higher scores than the boys.

DISCUSSION

Analysis by grade level shows that at the lower secondary level as well as at the upper secondary level, there were no gender differences. These separate findings were consistent with results from the investigations of gender differences on the mean scores computed from the pooled data on examination results. In conclusion, no gender differences were found in school-based examinations performance.

However, the present study observed that the girls scored higher marks than the boys at the earlier examinations (Semestral I examinations) when only half a year's work was tested. At the same time, the boys outperformed the girls during the end-of-year examinations (Semestral II examinations), based on the entire year's work. By the end of each year, the boys appeared to have caught up with the girls.

Results on the SAT-M test showed patterns of gender differences favouring the girls. In the MCQ section of the SAT-M there were no gender differences. The Singapore school system appears to prepare its students in handling multiple-choice questions from the onset of elementary school; training could have evened out differences in performance between boys and girls. On the other hand, the boys were more willing to risk and guess on difficult items as indicated by the lower mean of the number of omitted items.

Generally, it is held that girls could only excel in items that contained materials taught by the teacher. This hypothesis does not hold in this study. The section containing quantitative comparison items have a format that is not commonly used in the classroom. Kimball (1989) hypothesised that boys might have an edge over the girls in nonroutine items. This study indicated that girls were better than the boys in quantitative comparisons. As students are generally not exposed to such items formats, doing well in them would represent a significantly high level of mathematics reasoning ability among the girls.

In the SAT-M items, the girls' strengths lie in content-areas such as Arithmetic and Geometry. They were also very much at ease working on items accompanied by figures or diagrams. Such observations were also noted in studies on the general population (Kaur, 1990; Brandon, Newton and Hammond, 1987) whose results showed that girls achieved their highest scores in computation and Armstrong (1985) who reported no gender differences in spatial visualisation among his high school sample. However, the GEP girls' better scores at Geometrical and Algebra items were fairly unusual. Among achieving high school students, boys were considered to have higher spatial ability (Pattison & Grieve, 1984) and to be better at algebraic questions (Randhawa, Beamer & Lundberg, 1993). Nevertheless, Ferrini-Mundy (1987) has shown that with training and exposure to spatial elements, girls could perform equally as well as the boys.

Weiner and Robinson (1986) in their study on gifted seventh and eighth graders concluded that boys have a higher mathematical ability than girls. They found that ability is the best predictor of mathematics achievement. Many researchers (Becker, 1990; Stocking & Goldstein, 1992) have used the SAT-M as an instrument for the measurement of developed mathematical reasoning ability. Results from a 10-year longitudinal study (Benbow, 1992) on nearly 2000 mathematically gifted seventh and eighth graders have supported the predictive validity of the SAT-M for subsequent mathematics achievement at high school coursework. While SAT-M is well documented to register numerical ability (Lubinski & Benbow, 1992; Swiatek & Benbow, 1991; Benbow, 1992), school grades measure the level of mathematics proficiency skills. Hence, the findings from the present study have not been unexpected as the correlation analysis showed a moderately strong relationship between SAT-M scores (indications of ability) and school grades (indications of mathematics achievement).

Longitudinal studies (Benbow & Stanley, 1982; Brody & Benbow, 1990; Benbow, 1992) with mathematically precocious youngsters compared SAT-M scores obtained at junior high and again at senior high. Findings demonstrated a consistent higher performance of the boys compared to the girls throughout their secondary school career.

There are however a number of differences between the present study's sample and Benbow's longitudinal samples (Benbow & Stanley, 1982; Brody & Benbow, 1990; Benbow, 1992). The samples that Benbow used were mainly Caucasian-Americans and these students followed an accelerated course. In contrast, the present sample was mainly Chinese in ethnicity. The sample members were participants in an enriched programme which emphasised content differentiation both in breadth and in depth. Brandon, Newton and Hammord (1987)'s study using ethnicity as one of the variables reported that gender differences favouring female Grade 10 students among Caucasians were less than they were among Japanese-Americans, Filipino-Americans and Hawaiian students. Ethnicity (Okagaki & Sternberg, 1993) might have implication for the relationship between the value system upheld within a community and attitudes and beliefs which may in turn affect achievement outcomes.

Contrary to most studies, the gifted girls in the present study had significantly higher SAT-M scores than gifted boys.

Implications of the Study

This study has demonstrated that the Singapore sample of gifted females from the GEP were exhibiting a level of mathematics achievement comparable to their male counterparts. The investigation has shown that the generally expected lower female mathematics achievement was not present among the GEP students. The results of this study have given considerable support to the provision of a special programme for the gifted and talented. The GEP provides a challenging learning environment supported by positive attitudes and behaviours of teachers and parents who are informed of these students' potential. The significance of these provisions are that they have an impact on the gifted girls' achievement level in a subject generally considered to be a masculine discipline. Without intervention, female underachievement exists and is well documented by Terman's studies (Terman & Oden, 1925). The present study's results indicates that, even among gifted students, environmental interventions may enhance educational achievement, especially that of female. Education policies need to incorporate an increasing awareness of the needs of the gifted female so that they can realise their contribution to selves and nation.

Finally, there is the question of whether the finding of this study on gifted students could be applicable to other talented students who are not participants in the GEP.

Suggestions for Further Research

Findings and implications of the study need to be weighed in view of its limitations. Firstly, the data and results referred only to gifted students participating in the Singapore's Gifted Education Programme and not to other gifted students who are in the regular curriculum.

Secondly the GEP is housed in the country's premier schools. There is the possibility of an interaction of both programme and school setting effects on gender differences in mathematics achievement.

The limited generalisation of the findings suggest certain areas for further research at 2 levels. At the micro level, studies with a representative sample of gifted students from the regular curriculum can be carried out to provide data for comparison with the GEP students. Of interest would be areas in gender differences patterns, mathematics attitudes and mathematics attribution behaviour.

In addition, since the crux of any gender study rests on the relative position between boys and girls, research should examine the achievement levels for girls and boys separately over a period of years . Such findings would reveal how mathematics performance has changed for each sex. This would allow comparison of achievement levels between girls and boys to become more exacting and thorough.

Of educational interest is the role of intervention programmes to raise females' mathematics achievement. Studies could identify key features of the GEP that prove to be effective in raising female achievement in mathematics. The success of such programmes could be investigated in relation to the school climate and organisation. More information is needed to separate programme benefits from school effects such as single-sex setting, staff morale and school ethos.

On the macro level, future research should investigate how the curricula, pedagogical techniques and cultural factors interact with gender in impacting quantitative performance. Such studies could include comparison between gifted programmes across countries.

Table 1 t-tests between Females and Males on School-based Examinations Results by Level

Level	Female			Male			Effect Size	t-value (Prob)
	Mean	SD	N	Mean	SD	N		
Sec 1	49.983	8.966	414	50.103	9.335	752	-0.013	-0.22 (0.83)
Sec 2	50.442	7.914	356	49.733	9.678	677	0.078	1.27 (0.60)
Sec 3	49.674	8.241	340	50.102	9.357	511	-0.048	-0.70 (0.44)
Sec 4	49.904	8.389	300	50.485	9.213	514	-0.065	-0.92 (0.36)

Table 2 t-tests between Females and Males on Standardised Mean Scores of School Examinations by Level and by Semester

Exams	Female			Male			Effect Size	t-value
	N	Mean	SD	N	Mean	SD		
Semester I								
EM S1	413	50.80	9.94	712	49.53	10.02	0.127	2.06*
EM S2	353	51.38	8.67	659	49.26	10.58	0.213	3.43***
EM S3	337	48.11	9.47	511	51.24	10.17	-0.316	-4.57***
AM S3	338	50.20	9.27	510	49.87	10.47	0.033	0.48
Semester II								
EM S1	406	49.12	9.66	750	50.48	10.16	-0.136	-2.24*
EM S2	354	49.58	9.06	673	50.22	10.47	-0.064	-1.02
EM S3	338	49.89	9.57	509	50.07	10.30	-0.018	-0.26
EM S4	298	50.05	9.11	514	49.97	10.50	0.008	0.11
AM S3	338	50.66	9.40	505	49.56	10.38	0.110	1.60
AM S4	294	49.77	9.63	504	50.14	10.23	-0.037	-0.51
Semester I	516	49.76	8.62	842	50.07	9.31	-0.034	-0.62
Semester II	552	49.07	8.53	972	50.26	9.25	-0.132	-2.54*
Lower Sec	468	49.88	8.28	841	50.01	9.00	-0.015	-0.26
Upper Sec	378	49.29	8.23	642	50.27	9.28	-0.116	-1.75
Total	555	49.42	12.29	974	50.19	14.02	-0.057	-1.12

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3 **Summary Statistics of the Raw Scores from SAT-M and t-tests between Females and Males**

	Females (n=142)		Males (n=220)		Effect Size	t-value
	Mean	SD	Mean	SD		
SAT	50.26	0.47	48.16	9.65	0.261	3.54***
MCQ	33.41	3.25	32.54	5.99	0.171	1.79
Quan	16.85	2.01	15.62	4.16	0.354	3.77***
Algebra	14.84	2.06	14.47	3.58	0.120	1.48
Arithmetic	13.65	1.19	12.91	2.64	0.338	3.84***
Geometry	14.57	1.37	13.82	2.48	0.355	3.94***
Miscellaneous	6.90	1.31	6.61	1.84	0.176	1.97*
Figure	16.52	1.82	15.75	3.19	0.281	3.21***

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4 **Correlation Coefficients between SAT-M scores and School Exams Results**

N=347	Lower	Upper	SchExam
SAT-M	0.33353 (p < 0.0001)	0.32040 (p < 0.0001)	0.34644 (p < 0.0001)

	Female (n=138)			Male (n=209)		
	Lower (S1 & S2)	Upper (S3 & S4)	SchExam (S1 to S4)	Lower (S1 & S2)	Upper (S3 & S4)	SchExam (S1 to S4)
SAT-M	0.487 (p<0.0001)	0.482 (p<0.0001)	0.5262 (p<0.0001)	0.294 (p<0.0001)	0.276 (p<0.0001)	0.298 (p<0.0001)

Table 5 **Summary Statistics and t-tests between Females and Males on the Converted SAT-M Scores**

	Females (n=142)		Males (n=220)		t-value
	Mean	SD	Mean	SD	
MCQ (i)	31.76	4.06	30.67	7.48	1.79
Quan (ii)	15.80	2.68	14.16	5.55	3.75***
(i) + (ii)	47.56	5.72	44.83	12.39	2.83**
SAT Score	676	50	648	152	

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 6 **SAT-M Scores of Mathematically Precocious High School Students**

	Males		Females		t-value
Cohort	Mean	SD	Mean	SD	
First Wave[a]	691	75	652	72	3.5***
Second Wave	693	72	643	68	7.9***
Third/Fourth Wave	695	67	650	75	10.6***
National Sample of College bound Seniors[b]	494	121	444	110	204.1***
Singapore Sample	*648*	*50*	*676*	*152*	*-2.83***

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table is adapted from Benbow and Stanley (1982).
[a]Data taken from Cohn (1980)
[b]Data for the National Sample of College-Bound Seniors is obtained from the Admissions testing Program (1979)

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