

PAPER 4

**THE EFFECTS OF ACCELERATION ON STUDENTS'
ACHIEVEMENT IN SENIOR SECONDARY MATHEMATICS:
A MULTILEVEL MODELLING APPROACH**

Stream: Multilevel Analysis

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Abstract

Despite continuing curiosity about the effects of content acceleration on student performance there is little quantitative confirmation of the benefits of these programs. This research attempts to fill this gap considering four years of Victorian Curriculum and Assessment Authority (VCAA) data relating to achievement in mathematics. These secondary data constitute experimental data for content acceleration in that schools without acceleration programs provide control data. However, the acceleration decision is not taken randomly by schools so these data are only quasi-experimental in nature. The measures used for mathematical performance (Mathematical Methods and Specialist Mathematics scores) are accepted as reliable and valid by the Victorian education system. Controlling for individual characteristics such as gender and prior knowledge, and allowing for moderation effects due to school setting and school sector, the effects of content acceleration are estimated using multilevel modelling. The results suggest that content acceleration is beneficial, especially for students with higher prior knowledge scores. The quasi-experimental nature of the data means that only a tentatively causal relationship between acceleration and mathematical performance can be claimed. However, the statistical control of other factors means that this conclusion can be generalised to other states, other countries and, probably, to other subjects.

Introduction

Braggett (1992) defines accelerated programs (or acceleration programs) as courses of action that are adopted by schools to meet the needs of accelerated learners, where accelerated learners are referred to as students who have moved ahead of many of their age peers in one or more aspects of their learning because of the speed at which they work or the depth of understanding of which they are capable. As suggested by Kulik and Kulik (1984), the operational effects of acceleration may be defined by the attributes of time compression and speeding up of instruction.

Acceleration programs tend to follow the content mastery model or content model. According to VanTassel-Baska (1988), this curriculum model has proven to be successful with gifted populations at various stages of development and various domain-specific areas. The content model emphasises the importance of learning skills and concepts within a predetermined domain of enquiry and gifted students are encouraged to move as rapidly as possible through the content area. A typical approach to this type of model is one that presets an early mastery level of students, frequently requiring more advanced skills and concepts to be mastered one year earlier than normal. This program responds to the rate needs of groups of students, allowing the able to advance quicker through the traditional curriculum.

Several researchers have used empirical data to prove that content acceleration is beneficial to students. A meta-analysis of studies by Kulik and Kulik (1984), on a variety of acceleration programs, showed that, overall, talented students are equally or more successful academically in accelerated programs compared with talented same-grade non-accelerants and talented older students. In particular the study concluded that talented students gained almost nine-tenths of a grade-equivalent school year over their equal ability same-grade non-accelerants, and were not different in their performance to their new classmates who were one year older. However the studies in the meta-analysis include a number of subject areas, grade levels, types of acceleration, and student selection criteria, so the results do not specifically relate to programs in mathematics and in particular they do not refer to the mathematics program outlined in this study nor to the forms of academic achievement relevant to VCE.

Plunkett et al (2003) presented the results of an analysis of an accelerated program offered by a particular Victorian secondary college in response to the 1995

Bright Futures policy of catering for high ability students. In particular the study evaluated how the acceleration program had impacted on the entire year level, accelerants and non-accelerants. Plunket et al (2003) found that the acceleration program had been worthwhile and an effective method for students with high academic ability. In regards to academic performance students' overall VCE performances showed a trend for better overall results. Unfortunately this study could not attribute this academic achievement to the acceleration program as there was no control or comparison group. Within a school there cannot be a control group as that would mean that the school was denying the potential benefits of the acceleration program to high ability students.

Acceleration programs, involving the completion of a Year 12 mathematics study in year 11, have been introduced into a number of Victorian schools for over a decade. However, amongst a number of educators there is a concern that accelerated students may not perform as well as they should, being too young and unprepared to handle the pressure of a fast-pace course.

The purpose of this study is to provide statistical evidence that will address this concern by determining the effects of acceleration on the study scores for Specialist Mathematics (SM) and Mathematical Methods (MM) of students who undertook MM units 3 &4 a year earlier than their age peers, as compared to students of equivalent ability who undertook MM concurrently with SM at Year 12. In particular two hypotheses will be tested.

Hypothesis 1.

The SM results of accelerated students will be significantly higher than for non-accelerated age peers who have equivalent prior knowledge.

Hypothesis 2.

The MM results of accelerated students will not be significantly worse than those of non-accelerated age peers who have equivalent prior knowledge.

The study examines the effects of acceleration on VCE Mathematics study scores of students who completed both SM and MM in Victoria, over a four-year period (2001-2004). On average this involved for each year 5341 students from 341 schools with 829 students included in a content accelerated program. Univariate multilevel modelling, through the use of the statistical software package, HLM version 6, was used

to determine the effects of acceleration on the SM and MM study scores, taking into account students' prior knowledge, gender, school sector and setting.

Methodology

Students involved in this research come from classrooms in rural, suburban and urban settings throughout Victoria. Only students in the Catholic, Government and Independent school sectors are included allowing for both single sex and coeducational settings. Only students from schools with 4 or more students undertaking both MM and SM studies were included. This was done in order to improve the reliability of the data (VCAA, 2002 p.6). Acceleration may not be a practical option for schools with fewer students and the results achieved in such a situation may really just be a reflection of class size. However, this means that the results of this study will only be relevant to schools that offer both SM and MM with viable class sizes.

Levels of achievement in the Mathematical Methods and Specialist Mathematics studies were assessed through school-assessed coursework and examinations with total scores for each assessment and corresponding weightings as outlined in Table 1 below.

Table 1: Total marks and weightings of graded assessments for MM Units 3&4 and SM Units 3&4

| Assessment | Maximum marks | | Weighting (%) |
|---|---------------|--------------|---------------|
| | MM Units 3&4 | SM Units 3&4 | |
| School-assessed coursework | 100 | 100 | 34 |
| Examination: (Facts, Skills and applications) | 100 | 100 | 33 |
| Examination: (Analysis Task) | 110 | 120 | 33 |
| Total | 310 | 320 | 100 |

These marks give students a ranking in the group (or cohort) of students taking that study across the state in that year. A study score of 50 indicates that the student has finished at the top of the cohort while a study score of 0 indicates that the student has

finished at the bottom of the cohort and a study score of 30 indicates that the student has finished in the middle of the cohort. In general for any study about 65-70% of students obtain a study score between 23 and 37.

Students are also provided with a standardised GAT score for each area which is reported using the same scale that is used for the above study scores, that is a mean of 30 and a standard deviation of 7. GAT results are used by VCAA to monitor school-assessed coursework and school-assessed tasks. Although GAT results do not count directly towards VCE results, they do play an important role in verifying that school assessed coursework and examinations have been accurately assessed. For the purposes of this study, the GAT results of student's performance on questions relating to Mathematics, Science and Technology (GATMST) will be used as a measure of prior ability.

The study involves data from a population that has two levels, a student level (level 1) and a school level (level 2 or group level). Such a population is referred to as hierarchical or clustered. In past studies, the most common approach for the statistical analysis of multilevel data was to first either aggregate data to the group level, thus assigning the same group mean to each individual, or to disaggregate data to the individual level, thus treating individuals without reference to their group. Such conventional regression methods tend to focus too much on the individual and too little on the social or institutional contexts in which individuals are located. Multilevel models make it possible to analyse the levels of these structures simultaneously so consideration about the appropriate level of analysis becomes redundant (Plewis, 1998).

Multilevel modelling analysis, also often known as Hierarchical Linear Modelling (HLM), has been developed only recently. These models originated in the contextual analysis work of Robinson (1950), focused on the effects of social context of human behaviour and the mixed effects models first discussed by Eisenhart (1947). Hierarchical models, defined as the confluence of these two streams, developed in the 1980's with the first paper by Aitkin, Anderson and Hinde (1981). As mentioned in Heck and Thomas (2000) although there are numerous books to help in understanding univariate and multivariate data analytic methods using conventional methods of analysis, such as the general linear model in conjunction with ANOVA and regression, there are very few books that provide an integrated understanding of

univariate and multivariate multilevel analytic techniques. Similarly, these techniques are not really available in commonly used statistical software packages.

In multilevel modelling we want to know how a number of level 1 and level 2 variables affect a particular outcome variable. The aim of the analysis is to determine the direct effects of the individual and group level explanatory variables, and to determine if the explanatory variables at level 2 serve as moderators of the level 1 relationships (Hox, 1995). Hence, by focusing attention on the levels of the hierarchy in the population, multilevel modelling enables a better understanding of where and how effects are occurring (Browne et al, 2001). Through examining the variation in outcomes that exists at different levels, more refined theories can be developed about how explanatory variables at each level contribute to outcomes.

In conclusion, an analysis that models the way in which students are grouped within schools has a number of advantages. According to Goldstein (1995), it enables data analysis to obtain statistically efficient estimates of regression coefficients and by using the clustering information it provides correct more conservative standard errors, confidence intervals and significant tests. The 2-level models that will be investigated for each of the MM and SM study scores are provided below, with MM_{ij} and SM_{ij} indicating the MM and SM marks for the i th student at the j th school. The Greek letters indicate model parameters and it is assumed that the error terms, e_{ij} and u_{kj} are random but normally distributed with constant variance. The explanatory variables in these models are described in Table 2.

Model 1: Mathematical Methods

$$MM_{ij} = \beta_{0j} + \beta_{1j}ACCEL_i + \beta_{2j}GENDER_i + \beta_{3j}GATMST_i + e_{ij}$$

where

$$\beta_{kj} = \gamma_{k0} + \gamma_{k1}SETTING_j + \gamma_{k2}INDEP_j + \gamma_{k3}GOVT_j + u_{kj}$$

for $k=0, 1, 2$ and 3

Model 2: Specialist Mathematics ignoring Mathematical Methods Scores

$$SM_{ij} = \beta_{0j} + \beta_{1j}ACCEL_i + \beta_{2j}GENDER_i + \beta_{3j}GATMST_i + e_{ij}$$

where

$$\beta_{kj} = \gamma_{k0} + \gamma_{k1}SETTING_j + \gamma_{k2}INDEP_j + \gamma_{k3}GOVT_j + u_{kj}$$

for $k=0, 1, 2$ and 3

Model 3: Specialist Mathematics based on Mathematical Methods Scores

$$SM_{ij} = \beta_{0j} + \beta_{1j}ACCEL_i + \beta_{2j}GENDER_i + \beta_{3j}GATMST_i + \beta_{4j}MM_i + e_{ij}$$

where

$$\beta_{kj} = \gamma_{k0} + \gamma_{k1}SETTING_j + \gamma_{k2}INDEP_j + \gamma_{k3}GOVT_j + u_{kj}$$

for $k=0, 1, 2, 3$ and 4

Table 2: Explanatory Variables for Multilevel Models

| Construct | Variable | Measure |
|--------------------------------|-----------------|---|
| Acceleration | ACCEL | Assumes the value 1 if student is accelerated and 0 otherwise. |
| Gender | GENDER | Assumes the value 0 if student is male and 1 if female. |
| General Achievement Test (MST) | GATMST | Mathematics/Science/Technology component of the General Achievement Test (0-50) as reported to students. |
| School setting | SETTING | Based on gender composition of MM for each school. Assumes the values 0 if single-sex and 1 if coeducational. |
| Government Sector | GOVT | Assumes the value 1 for Government sector, 0 otherwise. |
| Independent Sector | INDEP | Assumes the value 1 for Independent sector, 0 otherwise. |

These hypothesised models can be fitted to the data allowing the removal of any insignificant school parameters ($p>0.05$). The coefficients are then interpreted with particular attention being paid to the coefficients for acceleration.

In the next section descriptive information is provided for the data before fitting the above multilevel models separately for each year of data. This allows the comparison of the estimated model coefficients over time. Finally, considering only students with GATMST scores above 45, the models are fitted separately for the period 2001-2002 and 2003-2004. This ensures sufficient data while still allowing a comparison of coefficients over time. Descriptive analyses are performed using SPSS version 14 while the multilevel models are fitted using HLM version 6.

Results

The summarised frequencies for the data are shown in Table 3. The number of schools for the entire period is estimated as the average number of schools in the periods 2001-2002 and 2003-2004. This was necessary because different school identifiers were used in these periods.

Table 3: Numbers of students

| | Number of students | Number accelerated students (%) | Estimated Number of schools |
|------------------------|--------------------|---------------------------------|-----------------------------|
| 2001 | 5311 | 756 (14.2%) | 342 |
| 2002 | 5403 | 810 (15.0%) | 345 |
| 2003 | 5442 | 882 (16.2%) | 340 |
| 2004 | 5209 | 867 (16.6%) | 337 |
| 2001-2004 | 21365 | 5209 (15.5%) | 374 |
| Government Schools | 10228 | 42 (8.2%) | 203 |
| Catholic Schools | 4256 | 749 (17.6%) | 80 |
| Independent Schools | 6881 | 1724 (25.1%) | 91 |
| Single sex setting | 5561 | 1696 (30.5%) | 156 |
| Co-educational setting | 15804 | 1619 (10.2%) | 591 |
| Girls | 8468 | 1327 (15.7%) | Not applicable |
| Boys | 12897 | 1988 (15.4%) | Not applicable |

As shown in Table 3 the number of students in the data set reached a peak in 2003, however the percentage of accelerated students in the data climbed from 14.2% in 2001 to 16.6% in 2004. The percentage of accelerated students varied significantly between school sectors with more than triple the acceleration rate for independent schools as opposed to government schools. Similarly the acceleration rate was three times higher for single sex schools than for coeducational school. Although the acceleration rates were similar for boys and girls, the number of boys in the data exceeded the number of girls by 50%. Interestingly, a loglinear analysis confirmed a significant fourth order interaction for these variables, suggesting that the percentage of accelerated students differed significantly between the genders when sector and setting were taken into account (Chi-Square = 14.06, df = 2, p = 0.001).

Table 4: Mean Scores

| | GATMST | MM | SM |
|------------------------|--------|-------|-------|
| 2001 | 37.48 | 35.57 | 30.59 |
| 2002 | 37.41 | 35.59 | 30.76 |
| 2003 | 37.01 | 35.96 | 30.84 |
| 2004 | 36.33 | 35.70 | 30.96 |
| Total | 37.04 | 35.71 | 30.79 |
| Government Schools | 36.53 | 34.76 | 29.66 |
| Catholic Schools | 36.83 | 34.91 | 29.61 |
| Independent Schools | 37.94 | 37.61 | 33.19 |
| Single sex setting | 37.74 | 37.17 | 32.50 |
| Co-educational setting | 36.80 | 35.19 | 30.18 |
| Girls | 37.77 | 35.72 | 30.85 |
| Boys | 35.93 | 35.69 | 30.68 |

Table 4 shows the mean values for GATMST, MM and SM for the students in the data. The GATMST and MM scores are higher than the average value of 30 because students who complete both MM and SM tend to have higher ability. There appears to have been a slight decline in the GATMST scores over the four years, however, this has been matched by a steady increase in SM scores over the period. Independent schools outperform the other two sectors in all cases and single sex schools

outperform co-educational schools. Finally, girls appear to score higher than boys in all cases, but especially in the case of GATMST scores. This is probably not surprising given the relatively small number of girls in the data.

The significance of the differences in Table 4 can only be accurately established by fitting multilevel models to the data in Table 5. The large number of tests performed for these models make it best to concentrate on the highly significant effects ($p \leq 0.001$) in Table 5. In the paragraphs below we interpret the impact of student variables (acceleration, gender and GATMST) and then the impact of the school variables (sector and setting).

Considering the effect of acceleration we see an insignificant effect on MM scores in all but one of the years. In 2002 there was a significant acceleration effect but only for single sex schools (SETTING=0), with accelerated students scoring on average one point higher than equivalent non-accelerated students. In the first SM model acceleration has a significant effect in all years with values ranging from 2.41 in 2002 to 2.76 in 2004. In the second SM model which controls for MM scores the acceleration is also significant. However, in 2003 the average acceleration affect is weaker for independent schools (1.93) than for Catholic and government schools (2.77). Girls show significantly better performance than boys for all years in the case of MM, except for independent schools in 2002. SM scores are also significantly higher for girls in 2001 and 2002 in the first SM model with much less convincing results in 2003 and 2004. However when we control for the effect of MM scores there is some indication of boys outperforming girls, particular in the case of single sex schools in 2002. A GATMST mark 10 points higher appears to raise MM and SM marks by about 4 points on average, however, when we control for the effect of MM in the second SM model this effects seems to almost disappear.

Table 5: HLM Analysis Significant Coefficients (**p ≤ 0.001, * p ≤ 0.05)

| Dependent variable | Independent variables | School Moderator | Parameter | Parameter Estimates | | | |
|--------------------|-----------------------|------------------|---------------|---------------------|---------|---------|---------|
| | | | | 2001 | 2002 | 2003 | 2004 |
| MM Score | Intercept | | γ_{00} | 19.93** | 19.58** | 21.42** | 22/03** |
| | | Setting | γ_{01} | -1.66** | -1.22** | -1.31** | -1.59** |
| | | Independent | γ_{02} | 1.99** | 2.52** | | 2.37** |
| | Gender | | γ_{10} | 0.71** | 0.87** | 0.89** | 0.50* |
| | | Independent | γ_{12} | | -0.68* | | |
| | GAT | | γ_{20} | 0.41** | 0.40** | 0.36** | 0.36** |
| | | Independent | γ_{22} | | | 0.06** | |
| | Acceleration | | γ_{30} | -0.02 | 1.10** | 0.22 | 0.03 |
| | | Setting | γ_{31} | | -1.07* | | |
| SM Score | Intercept | | γ_{00} | 14.31** | 15.40** | 18.08** | 17.28** |
| | | Setting | γ_{01} | -1.73** | -2.42** | -2.29** | -1.66** |
| | | Independent | γ_{02} | 2.18** | 2.53** | | 3.13** |
| | | Government | γ_{03} | | -0.78 | | |
| | Gender | | γ_{10} | 0.44* | 1.51* | -0.79 | -0.21 |
| | | Setting | γ_{11} | | | 1.63* | |
| | | Government | γ_{13} | | | | 1.00* |
| | GAT | | γ_{20} | 0.41** | 0.40** | 0.32** | 0.34** |
| | | Independent | γ_{22} | | | 0.07** | |
| SM Score | Intercept | | γ_{00} | -6.94** | -4.99** | -4.53** | -4.49** |
| | | Setting | γ_{01} | | -0.73** | | |
| | | Independent | γ_{02} | 0.44* | 0.32* | | 0.53** |
| | | Government | γ_{03} | 0.51* | -0.85** | | |
| | Gender | | γ_{10} | -0.05 | -0.85** | -0.15 | -0.31* |
| | | Setting | γ_{11} | | 0.86** | | |
| | | Government | γ_{13} | -0.35* | | | 0.36* |
| | GAT | | γ_{20} | -0.01 | -0.02* | -0.05** | -0.02* |
| | | Independent | γ_{22} | | | 0.01* | |
| MM | Acceleration | | γ_{30} | 2.59** | 1.84** | 2.77** | 2.86** |
| | | Independent | γ_{32} | | | -0.84* | |
| | MM | | γ_{40} | 1.04** | 1.02** | 1.01** | 0.99** |

Now considering the school variables, the results in Table 5 suggest a significant increase in MM scores of 1.22 to 1.66 points on average in the case of single sex schools. MM marks were also higher by 1.99 to 2.52 points on average for independent schools in all years except 2003. Similarly the first SM model suggested higher scores for single sex schools in all years and higher scores for independent schools except in 2003. However, after controlling for MM scores single sex schools significantly outperformed coeducational schools only in 2002, while the effects for independent and government schools also tended to be weaker.

This multilevel analysis therefore seems to support the two hypotheses suggesting that although acceleration tends to improve performance in the case of SM scores this is not generally the case for MM scores. The effect of acceleration was certainly stronger than the gender effect and was also generally higher than sector or setting effects, especially after controlling for MM scores.

Next we consider HLM models when only students with GATMST scores above 45 are considered. The smaller samples made it appropriate to combine the data for 2001 and 2002 as well as the data for 2003 and 2004. It was not possible to combine the data for all four years because the method of school identification changed dramatically at the end of 2002. Table 6 suggests that in the first two year period the effect of acceleration on MM scores was not significant. However, this changed in the 2003-2004 period with accelerated students scoring an additional 1.55 points on average when other variables were controlled. The first model for SM scores showed a significant increase of on average 4.17 points for accelerated students in the first 2 year period increasing to 5.51 points in the second 2 year period. However, after controlling for the effect of acceleration on MM scores the second SM model showed an acceleration effect of only 3.31 in the first 2 year period and 3.83 in the second 2 year period. Gender effects were basically insignificant for this group of students and any GATMST effect was ignored due to the small range of GATMST values in this group. It seems therefore that for students with higher prior knowledge the effect of acceleration is particularly beneficial.

In the case of MM scores single sex schools performed significantly better in the first 2 year period but not for the second 2 year period, but independent schools achieved significantly better results for both periods, on average 2.24 to 2.79 points

higher than Catholic or government schools. After controlling for MM scores, school setting and sector effects were minimal.

Table 6: HLM Analysis Significant Coefficients for GATMST above 45

(** $p \leq 0.001$, * $p \leq 0.01$)

| Dependent variable | Independent student variable | School Moderator | Parameter | Parameter Estimates | |
|--------------------|------------------------------|------------------|---------------|---------------------|-----------|
| | | | | 2001-2002 | 2003-2004 |
| MM Score | Intercept | | γ_{00} | 39.62** | 37.74** |
| | | Setting | γ_{01} | -1.64** | |
| | | Independent | γ_{02} | 2.24** | 2.79** |
| | Gender | | γ_{10} | 0.27 | 0.57 |
| | Acceleration | | γ_{30} | 0.55 | 1.55** |
| | | | | | |
| SM Score | Intercept | | γ_{00} | 32.88** | 32.10** |
| | | Independent | γ_{02} | 2.47** | 3.24** |
| | Gender | | γ_{10} | 0.54 | -0.34 |
| | Acceleration | | γ_{30} | 4.17** | 5.51** |
| | | | | | |
| SM Score | Intercept | | γ_{00} | -7.68** | -5.37** |
| | | Independent | γ_{02} | | 0.49* |
| | Gender | | γ_{10} | -0.28 | -0.68* |
| | Acceleration | | γ_{30} | 3.31** | 3.83** |
| | MM | | γ_{40} | 1.06** | 0.99** |

For the sake of completeness Table 7 presents the error variances for each of the models considered above. These are the estimated variances for the level one (e_{ij}) errors. This table shows similar variances over the period 2001-2004. In the case of

students with higher prior knowledge (GATMST over 45) there appears to be a higher error variance, suggesting that this group is not as homogeneous as might be expected.

Table 7: Level One Error Variances

| Dependent Variable | Mathematical Methods (MM) | Specialist Mathematics (SM) | SM controlling for MM |
|-----------------------------|---------------------------|-----------------------------|-----------------------|
| 2001 all students | 16.48 | 23.77 | 6.14 |
| 2002 all students | 16.15 | 23.53 | 6.49 |
| 2003 all students | 17.45 | 23.90 | 5.95 |
| 2004 all students | 17.17 | 23.82 | 6.49 |
| GATMST over 45 2001-2002 | 19.00 | 29.45 | 7.85 |
| GATMST over 45 2003-2004 | 20.27 | 28.66 | 8.41 |

Conclusions

In order to quantify the effect of content acceleration on VCE mathematical performance, data obtained from VCAA was manipulated and a multilevel modelling analysis, a methodology that takes into account the effects of student and school level factors simultaneously, was conducted. The findings indicated that, as expected, acceleration has a significant positive effect on the SM but not necessarily the MM study scores. For accelerated students who scored in the top 2% for their GATMST (≥ 45) this improvement in scores was particularly dramatic.

This is an important finding because it lays to rest the concerns of many educators regarding the use of content acceleration for mathematics in Victorian schools. It also puts pressure on schools which do not have such acceleration programs to consider their introduction. It appears that accelerated students are not disadvantaged; indeed it appears that these students will obtain higher university entrance scores, providing them with better options for course selection at tertiary level.

However, the study has several limitations. A complete analysis of all the effects of acceleration, such as attitude, social, emotional, or behavioural characteristics for students undertaking an acceleration program was not possible. This study focused

only on the effects of acceleration on students' mathematics achievement at the VCE level. Secondly the study assumes that all students have the same experience of the curriculum content. In particular students' mathematical experiences or involvement in other intervention programs are ignored in this study. For example the data does not identify students who have undertaken a university mathematics subject at Year 12. These students may or may not have been accelerated and even though there is no available research to verify this, undertaking a university mathematics subject may also have affected the study scores in both SM and MM.

There may also be bias in the data in that students who completed Mathematical Methods in year 11 as part of an acceleration program and then decided not to continue with Specialist Mathematics in year 12 and not considered. This bias would probably favour the acceleration option. Furthermore the study assumes that students have been correctly placed in or out of an acceleration program. Inappropriate placement of students in an acceleration program may therefore also have biased the results, this time in favour of the non-acceleration option.

The use of pre-existing VCAA data, limits the variables that can be controlled for in this study. The impact of socio-economic backgrounds is particularly relevant but not available from these data. Another limitation for this study concerns the use of GATMST scores to identify students of equivalent ability in mathematics. In future research, the recent state-wide results of students' numeracy skills obtained when students are in years 5, 7 and 9 will provide a better indicator of 'prior ability'. But probably the most serious limitation of the study occurs because the decision to offer an acceleration program in a school is not based on the toss of a coin. The factors which influence this decision, such as school size, student motivation, teacher differences are also likely to have biased the results in favour of acceleration.

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