Cohort size, sex and socio-economic status as predictors of success in Year 12 Physics in Perth, 1987-1997

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A variety of factors are associated with students' achievement in secondary school physics, including cohort size – the total number of students studying Physics in the school – and socio-economic status. Earlier studies also showed boys achieving better in Physics, while more recent research has shown better results for girls. Statistical analysis of the results of 25,682 Year 12 physics students from 99 schools in the Perth metropolitan area explored three factors related to performance in the physics course. Results were also analysed in terms of the schooling sectors – state, Catholic, high fee non-Catholic (grammar school) and low fee non-Catholic (smaller Christian and other independent schools) – from which students were drawn. Cohort size and socio-economic status were found to be strongly correlated with physics success, while sex was not found to have a significant correlation with achievement.

Introduction

Several different factors might be conjectured to effect student achievement on standardised state-wide achievement tests such as the Western Australian Tertiary Entrance Examinations (TEE) in a systematic way (that is, at a level beyond student individual differences). Three such factors – cohort size (the total number of students in a school studying the subject), sex and socio-economic status – were explored in relation to the TEE results of Perth students over the eleven year period from 1987 to 1997 (inclusive). Obviously, the data are somewhat old now, however the findings remain relevant to considering factors relevant to success in secondary school physics, particularly those that are perhaps less intuitively obvious.

Altinok and Kingdon (2011) conducted a meta-analytical study of Trends in International Mathematics and Science Study (TIMSS) data from forty-seven countries. They found that, in agreement with other studies on the achievement effects of class size (e.g. Wößmann & West, 2006), class size had a negligible effect on student achievement. This flies in the face of the 'conventional wisdom' that smaller class sizes lead to enhanced achievement. Hattie's (2008) work supports the contention that class size is not strongly correlated with student success. Kenny and Oppedisano (2013) found evidence of enhanced mathematics achievement for students in *larger* classes using PISA data, however, only the results for the UK were statistically significant.

Class size data were not available for the present study, but the total number of students who studied Physics *in each school* – the cohort size – during the eleven years of the study was taken as a variable and compared with achievement in Physics. We are not aware of earlier studies that have explored this particular relationship. A multi-level modeling approach to Hong Kong's PISA data by Sun, Bradley & Akers (2012), however, showed a positive correlation between school size and science achievement. While there may have been some effects due to class size in the present study – some schools average only six or less students per year, for example – we felt that the cohort size effects, particularly with larger cohorts in schools that teach multiple classes in the same course, were more likely to be influential on achievement in this study than class size alone.

While girls tend to participate in secondary school physics at a lower rate than boys, their achievement is typically at similar levels, when variables other than sex are controlled. Earlier studies such as those by DeMars (1997, citing Erickson and Erickson (1984)) and Young and Fraser (1993) showed boys achieving higher grades in Physics than girls.

Hildebrand's (1998) study of Physics in the Victorian Certificate of Education (VCE – a similar state-wide Grade 12 assessment program, although with a larger school-based component) showed a dramatic narrowing of the gap, and in fact a reversal, with girls achieving higher grades than boys. More recently still, Fischer, Schult and Hell (2013) found that female students perform better than male students, and that this effect is even more dramatic when results are controlled for basic intelligence. Given this changing picture and the potential gap between perception and reality, we felt that it was important to explore whether sex was a significant predictor of success in TEE Physics.

Finally, a persistent research finding has been the correlation between relative wealth and academic success. More than thirty years ago, Coleman et al. (1966) and Jencks et al. (1972) suggested that socio-economic status was a stronger determinant of academic achievement than school related effects. Although this has been disputed (e.g. by Bowles & Levin, 1968; Yeakey, 1983), more recent studies (e.g. Young & Fraser, 1993, and those cited in Kahlenberg, 2003) have also shown such a correlation between socio-economic status and academic achievement.

Zady et al. (1998) and Marcon (1999) have explored possible reasons for this effect, although not at the senior high school level. Bowden and Doughney (2010) found that students from lower socioeconomic strata were less likely to aspire to attend university and this 'aspiration gap' (their term), may influence students' achievement. The present study does not focus on causality, but simply explores the correlation between socio-economic status and students' achievement in Physics.

Method

In the context of an on-going study into the construction of educational inequality and advantage in upper secondary school physics (Geelan, 2003; Geelan, Wildy, Louden & Wallace, 2004; Wildy, Louden & Wallace, 1998; Wildy & Wallace, 1994, 1995), a large scale statistical analysis was conducted of the results of Year 12 physics students in 99 metropolitan Perth secondary schools in the eleven year period 1987 to 1997 (inclusive).

Only 'first attempt at Year 12' (on the part of students) secondary schools were chosen for the study. Institutions catering for mature age students and those making repeat attempts at the subject were excluded from the sample. Other institutions that allowed students to enrol privately rather than attend school were also excluded. Our data set consisted of a comparable group of seventeen and eighteen year old students attending schools and attempting the Year 12 physics course for the first time.

We omitted schools presenting a total of less than twenty-two students in the course of the eleven years (i.e. below an average of two students per year). Such small cohorts arose either because the school did not begin offering Year 12 Physics until late in the eleven year period or because their enrolments were very small. We argue that these very small samples did not allow valid comparisons to be made. A final exclusion was the set of students who received an over-all Tertiary Entrance Examination (TEE) Physics score of zero (0) who were classified as 'nontriers'.

Whenever the words 'score' or 'results' are used in this paper, it is the final TEE score that is the intended meaning. Students' final TEE Physics score is expressed as a percentage, and is made up of 50% school based assessment and 50% from an external examination. The school assessment is moderated using both the external exam and the Australian Scaling Test (ASAT). Of the total group of 27,392 students who registered for TEE Physics in the 99 schools included in this study during the eleven year period, a total of 1,710 were classified as non-triers. This corresponds to 624 of 12,316 (5.1%) students presenting in non-government schools and 1,086 of 15,076 (7.2%) students in government schools.

These exclusions left a total student group in the study of 25,682 students, in 99 schools. Of these, fifty-four were government schools, and the remaining forty-five were non-government. For the purposes of some analyses, the non-government sector was further divided into three categories – Catholic schools (twenty-three), high fee non-Catholic schools (i.e., the prestigious and expensive, well established grammar school sector, abbreviated as HFNC - there were thirteen of these) and low fee non-Catholic schools (i.e., usually small, often relatively new private (often Christian) schools, either parent-controlled or part of a small association, abbreviated as LFNC - nine schools fall into this category).

In the course of the analysis, three main factors were considered, based on previous research in the project (Wildy, Louden & Wallace, 1998): mean cohort size, sex, and socioeconomic status.

Cohort Size

There is a well-known debate about the perceived advantages of small class size (e.g. Boyd-Zaharias, 1999; Deutsch, 2003; Johnson, 2002; Reynolds, Reagin & Reinshuttle, 2001). Our study deals with cohort rather than class size. Here we refer to the total number of students in a school presenting for Physics in Year 12. We found that larger cohort size was strongly correlated with high achievement in TEE Physics.

Mean cohort sizes were calculated for each school, by dividing the total number of students who completed the course at the school by the number of years in which students from that school presented results. For 72 of the 99 schools in the study this was the whole eleven years. One school presented students in only three years, two schools four years, two schools five years, and a further twelve schools for between six and ten years. The smallest mean cohort size was six students per year, and the largest was seventy-one, with the mean of cohort sizes equal to 24.5 and the standard deviation 14.2. No data were available about the number and size of individual class groups in each school, so the measure relates to the average total number of students taking Physics in the school each year. In general, the cohort sizes were quite stable across the period studied, except in the very small schools, which often fluctuated more dramatically in percentage terms, simply because of the smaller groups. The Pearson correlation coefficient across the entire study between mean school cohort size and Physics score was found to be + .545, significant at the 0.01 level.

When this is divided by sectors, the results are as shown in Table One.

SECTOR	CORRELATION OF MEAN COHORT SIZE AND PHYSICS SCORE
Government, n=54	+ .641**
Catholic, n=23	+ .446**
High fee non-Catholic, n=13	- .083
Low fee non-Catholic, n=9	+ .212

Table 1: Mean cohort size vs Physics achievement, school level, by sector.
** = Significant at 0.01 confidence level.

Sex

The mean physics score for the entire student group (n=25,682) was 67.32 marks (out of 100). The mean for all male students was 67.37 and the mean for all females 67.22.

In each sector, except the low fee non-Catholic group, the mean female scores were slightly below the group mean and the male scores slightly above, but this difference was generally very small (less than 1 mark out of 100) and not statistically significant.

The issue of single-sex versus mixed-sex classrooms is difficult to disentangle from that of socio-economic status in this instance, since the single-sex grammar schools also tend to be the most affluent, highly resourced and selective schools.

The overall point-biserial correlation between sex and achievement in Physics was .006, and is not statistically significant, even with a sample of this size. Divided by sector, these results are as shown in Table Two.

SECTOR	CORRELATION OF SEX AND PHYSICS SCORE
Government, n=54	+ .006
Catholic, n=23	+ .061**
High fee non-Catholic, n=13	- .061**
Low fee non-Catholic, n=9	+ .045

Table 2: Sex vs Physics achievement, school level, by sector.
** = Significant at 0.01 confidence level.

Socio-economic Status

While a finer-grained analysis of the relationship between socio-economic status (SES) and Physics success would look at the SES of individual students, these data are sufficiently sensitive as to be very difficult to obtain. For this reason, the SEIFA index of Urban Advantage (Australian Bureau of Statistics, 1998) was used, along with the postcode districts within which schools were situated, as an approximation for the socio-economic status of students. This approach has some obvious flaws – students often travel some distance from home to attend school, and postcode districts often include areas of quite different SES – however, such an estimate has been shown to provide an adequate approximation for studies of this type (Ainley, Graetz, Long & Batten, 1995).

The Pearson correlation between socio-economic status and Physics score for individual students was + .186, significant at the 0.01 level. Table Three shows this result analysed by sector.

SECTOR	CORRELATION OF SES AND PHYSICS SCORE – STUDENT LEVEL
Government, n=13,990	+ .222**
Catholic, n=5,751	+ .103**
High fee non-Catholic, n=4,983	+ .067**
Low fee non-Catholic, n=958	- .061

Table 3: Socio-economic status vs Physics achievement, student level, by sector.
** = Significant at 0.01 confidence level.

SECTOR	CORRELATION OF SES AND PHYSICS SCORE – SCHOOL LEVEL
Government, n=54	+ .633**
Catholic, n=23	+ .313
High fee non-Catholic, n=13	+ .177
Low fee non-Catholic, n=9	+ .045

Table 4: Socio-economic status vs Physics achievement, school level, by sector.
** = Significant at 0.01 confidence level.

When the comparison is made at the school level, the observed correlation is much stronger: r = + .505 for the entire group (significant at 0.01 level), simply because similar students are grouped together. Within particular sectors, the correlation at school level between SES and achievement is as shown in Table Four

Discussion

The results for cohort size – the average total number of Year 12 physics students taking the subject in a school each year – are intriguing, and were perhaps the most surprising of the study. The correlation was strong and positive (larger cohorts correlates to higher scores) in the government and Catholic sectors. It was negative but negligible in the high fee non-Catholic (grammar school) sector and positive but not significant in the low fee non-Catholic sector. In general, across all students, the results suggest that a student in a school where there are more students taking Physics is more likely to succeed in Physics than students in schools with smaller cohorts. This may to some extent be a selection effect, in that students (and parents) who want to succeed in Physics, select schools with a reputation for good physics programs.

The strong correlation between the number of students taking Physics in a school and the success rates may be related to factors in addition to selection effects. For example, schools with larger cohorts might develop greater levels of collegiality, support and resource sharing between multiple physics teachers. Similarly, schools with larger cohorts might develop more specialisation among teachers. For instance, in a school with seventy Year 12 physics students, a teacher may have responsibility for two Year 12 physics classes and two Year 11 physics classes, that is, be responsible only for teaching senior Physics. In contrast, in a school with only ten Year 12 Physics students, the teacher's workload would be built around teaching courses other than Physics, such as mathematics and junior high science.

This finding may also reflect the fact that some schools with large cohorts have the capacity to retain teachers with strong physics backgrounds and high profiles in professional associations (Wildy & Wallace, 1995).

Over the whole student group, there was a very small negative correlation between physics success and sex, with boys scoring slightly higher than girls. However, the correlation was close to zero and was not statistically significant. The findings for the Catholic and HFNC sectors were statistically significant, probably due to the very large size of the samples, but at a very low level of correlation. It is interesting to note, however, that almost three times as many boys as girls completed the Year 12 Physics course. We note data suggesting that girls who complete Year 12 Physics may be more academically able than the boys. The mean ASAT score for female students was 69.14 and the mean ASAT score for male students was 67.34 (out of 100). Given that the boys and the girls showed almost identical final TEE Physics scores, we might suggest that the girls were to some extent under-achieving in Physics, compared to their ability.

Our analysis of socio-economic status (SES) in relation to Physics scores indicates that the more affluent students are, the more likely they are to achieve success in Physics.

When the data were analysed by correlating individual students' scores and socio-economic status (approximated using the Index of Urban Advantage and the school postcode), the correlation was positive and statistically significant for the students in the entire study, and also for the government, Catholic and HFNC school sectors. The correlation was negative, of negligible size and not statistically significant for the LFNC sector.

When these data were aggregated by schools (that is, mean school score versus SES), the effect was even more marked because the students were more tightly grouped in terms of their similarities. The correlations for the study as a whole and for the government sector were large, positive (i.e. more affluent students were more successful) and statistically significant. Correlations for the Catholic and HFNC sectors were positive and smaller, but not statistically significant at a 0.01 level of significance. The range of socio-economic status represented by the HFNC sector was sufficiently narrow that this result is unsurprising for that sector.

The result for the low fee non-Catholic sector was a strong negative correlation, which is surprising in terms of the results in the other sectors, however this sector was very small (nine schools in total), and one particular school, which was in a very affluent suburb, had experienced very small and fluctuating cohort sizes in Physics over the period of the study, and very poor Physics scores. If this school was removed from the data set, the correlation was close to zero.

Achievement in schools with smaller cohorts was much more variable. In particular, more students in schools with small cohorts achieved very low scores in Physics (10-30%) than occurred in schools with larger cohorts.

Conclusion

This paper is one in a series from our long term study of the construction and perpetuation of advantage in society. We are interested in the notion that those who are already socially and economically advantaged often receive schooling that helps to maintain and expand that advantage, whereas those who are already disadvantaged may not receive benefits from their schooling that will allow them to change their circumstances. This statistical piece of the study does not allow strong causal claims to be made about *why* there is a correlation between socio-economic status and success in Physics, because it looks only at outcomes.

The factors that lead to success and failure in Physics may be correlated with home resources and support for learning, parents' educational level and ability to support students' learning or a large number of other factors, rather than to what happens to them at school. However, the finding that science education is not serving as a means of overcoming students' disadvantages, and may even be perpetuating them, is worthy of further research attention.

It was heartening to see that sex was not a significant predictor of success in Physics, and that male and female students were achieving at very comparable levels. During the period covered by this study, there were still almost three times as many boys as girls taking Physics, however, and there is continued scope for encouraging motivated girls to choose to study Physics.

Cohort size is in some ways the most interesting finding of this study. It was impossible to determine actual class sizes from the data available, but anecdotally and from other parts of the study, it seems as though class sizes around thirty are not a significant impediment to success in Physics.

None of these three factors *determines* students' success (or otherwise) in Physics – there are numerous other factors in play, relating to the student, teacher, parents and school context. There is value, however, in being aware of factors that have implications for building students' access to Physics, and subsequent related professional careers.

Repeating this study with newer data – since the relationship between sex and achievement in Physics in particular seems to be a 'moveable feast' – and in more Australian states and internationally, has the potential to inform efforts to invite and engage more students to study and succeed in Physics.

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