Exploring the 'Hard Facts' around STEM in Australia: Females, Low Socioeconomic Status and Absenteeism

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Abstract

International research suggests that approximately 75% of the fastest growing occupations require skills in STEM (Becker & Park, 2011). This is problematic when recent Australian data highlights the underrepresentation of individuals in STEM-related subjects and professions who are Indigenous, female, or from low socioeconomic status (SES) backgrounds (Office of the Chief Scientist, 2016). Substantive research exists for each of these sub-populations and the factors impacting participation and achievement in schooling generally. This study focuses on a single cohort of female secondary students from Year 10 through to Year 12 attending a school in a low SES location. Two key variables were targeted: participation; and, rates of absenteeism with comparisons across those enrolled in STEM and non-STEM subjects. Data were provided by the school, which comprised both an all-female and co-educational campus on the one site. As such, many of the confounding variables (e.g., leadership, teachers) associated with comparisons of this type were consistent across the site. Non-parametric tests were applied with significant differences identified between female students across the two campuses for particular year levels. This pattern of difference highlights the need for further research to explore underlying variables, such as student cultural background that may account for these findings.

Introduction

In many countries, a skilled workforce in science, technology, engineering and mathematics (STEM) is considered a high priority for guaranteeing future economic prosperity in a competitive global economy. In Australia, the current STEM emphasis is about ensuring our youth has the intellectual capacity, knowledge and employability skills for an ever-changing workplace where 75% of future occupations are likely to require STEM-related skills (Beck & Park, 2011; Office of the Chief Scientist, 2012). While we appreciate that jobs and growth are important it should be acknowledged that this is a narrow view of the importance and value of STEM with the STEM Partnerships Forum (2017) acknowledging "*the benefits and transferability of STEM and ICT skills across all careers and in life generally*" (STEM Partnerships Forum, 2017, p. 6). Education is pivotal if we are to ensure that students develop not only foundational knowledge and skills but also an aptitude for independent thinking required of life-long learners capable of navigating future career opportunities while actively participating as informed citizens. Achieving this goal requires new ways of looking at STEM education (Paige, Caldwell, Elliott, O'Keeffe, Osborne, Roetman, Lloyd, Comber, & Gosnell, 2018).

However, there is an issue in many western countries with mounting evidence highlighting inequities and educational gaps for particular groups within the general population (National Academies of Sciences, Engineering, and Medicine, 2016; Office of the Chief Scientist 2016). In Australia, these gaps have been identified consistently over time in relation to Indigeneity, gender, geographical location, and socioeconomic status (SES) (McConney & Perry, 2010; Panizzon, 2009; Thomson, De Bertoli, & Buckley, 2012). Most of the research available about the participation and achievement of these groups of students tends to be generic. Within the STEM area specifically, many of these studies have involved the secondary analyses of data made available through the Programme for International Student Assessment (PISA), which is conducted internationally every three years. From these analyses, a key variable often linked to the achievement of Indigenous and Torres Strait Islanders students and those from low SES backgrounds is absenteeism, which is not surprising given that reduced time at school limits opportunities for learning (Bentley & Cazaly, 2015).

The comparative analysis presented in this paper investigates absenteeism and participation in STEM versus non-STEM subjects for a cohort of female students attending a school comprising both an all-female campus and co-educational campus. Access to such a unique context provides the opportunity to identify patterns and connections across these complex variables. Hence, this paper does not discuss integrated STEM and programs for implementation but rather aims to advance our current understanding around the complexity of factors impacting female participation in the STEM area. The paper discusses key findings from previous research regarding females in STEM, absenteeism and the impact of low SES on student participation at school. Following this the context of the school is described along with the research questions and methods used to explore these questions. The findings and critical insights gained from the statistical interrogation of the data are presented along with the implications for further research in the area.

Participation in STEM-related subjects and ongoing professions

Despite concerted policy efforts in many developed nations, including Australia, the discourse around STEM participation highlights the following poignant statistics.

- Australia is falling behind many other countries in STEM participation and performance (Marginson, Tytler, Freeman, & Roberts, 2013).
- Enrolments in STEM subjects are significantly less in schools located in low SES locations (Hackling, Murcia, West, & Anderson, 2013).
- Factors impacting female selection of science and mathematics subjects in the senior years are known (Fullarton & Ainley, 2000; Panizzon, 1997).
- A low SES background impacts students' participation, achievement and aspirations in STEM (Chapman, Laird, & Kewal-Ramani, 2010).

Females and their underrepresentation in STEM

Concerns about female underrepresentation in STEM have been observed and debated since the early 1970s (Bøe, Henriksen, Lyons, & Schreiner, 2011; Kanny, Sax, & Riggers-Piehl 2014) with only modest improvement in STEM participation noted.

> *Although the proportion of women in engineering, manufacturing and construction is small, it also increased slightly, from 23% to 28%, over the past decade. But in 2012, only 14% of young women who entered university for the first time chose science-related fields, including engineering, manufacturing and construction; by contrast, 39% of young men who entered*

> *university that year chose to pursue one of those fields of study*. (OECD 2015, p. 27)

In Australia, despite considerable policy activity and programs to address gender disparity (Rennie, 2010), female participation in STEM has not altered substantially over two decades (Marginson et al., 2013). Explanations for this gender disparity have changed over time and across disciplines. Historically, unequal representation was attributed to females having less aptitude for STEM subjects, lower mathematical ability, lower self-concept and interest in STEM-related subjects (Eccles, 2009). However, substantial research has found little empirical support for these claims (Xie, Fang, & Shauman 2015). More recently, Bøe et al. (2011) and Archer, DeWitt, Osborne, Dillon, Willis and Wong (2012) have posed that socio-cultural factors and constraints, rather than student ability, have constituted the most powerful explanatory factor behind gender disparity in STEM. These views were corroborated and investigated further by Kanny et al. (2014) using a comprehensive meta-narrative analyses to explore the gender gap around STEM at a university level. Their findings provide an array of barriers to STEM participation including:

- individual student background characteristics (e.g., socio-economic status, race, ethnicity);
- structural barriers in K–12 education (e.g., schools, teachers, pedagogy, curriculum, achievement, classroom structure and standardised testing);
- psychological factors;
- individual values and preferences (e.g., self-confidence, self-concept, sense of belonging);
- family influences and expectations (e.g. gender-role socialisation); and,
- student perceptions of STEM fields (e.g. perceived rewards/challenges).

While these factors are obviously relevant to the participation of secondary female students in STEM there are others. For example, Steinke (2017) found that around the age of 12, once highly confident and capable female students tended to lose interest in STEM. DeWitt and Archer (2015) ventured further in their work suggesting that early adolscence appears a critical time in the formation of occupational and study aspirations, particularly in relation to science.

Low socioeconomic status and participation in STEM

SES as a variable for school participation and achievement in scientific and mathematical literacy has been brought into focus over the last two decades by large-scale global assessment programs, such as PISA. However, the relationship between SES and STEM is complex, not the least because of the range of definitions and parameters by which both are conceptualised. For example, SES may be determined by various criteria, such as economic, social and/or cultural capital. Ignoring these contentions in delineating both SES and STEM, there is clear consensus in a number of western countries that a higher SES, irrespective of how it is measured, is linked consistently to students selecting more demanding school subjects, including STEM (Henderson, Sullivan, Anders, & Moulton, 2017). In the United Kingdom, Gorard and See (2009) found that student participation in school science was stratified by SES. Similarly, in Australia, Tytler, Osborne, Williams, Tytler and Cripps-Clark (2008) recognised that students from middle to high SES backgrounds were more likely to select and persist with STEM subjects for longer. While these studies identify a clear link between higher SES and STEM participation generally in secondary school, work in the United States by Niu (2017) found that "*the gap between female and male students in STEM enrolment narrows with the increase of family SES*" (p. 68). In terms of schools, Forgasz and Leder (2017) found that females attending single-sex schools were more likely to select chemistry, physics and higher-level mathematics subjects in Years 11-12 than their peers in co-educational schools.

Rates of absenteeism

School attendance is recognised as contributing to academic achievement and the development of social and work-related skills (Skedgell & Kearney, 2018). This research clearly confirms that school absenteeism can be linked to lower academic achievement and engagement that also affects social development (Balkis, Arslan, & Duru, 2016). While high levels of absenteeism can be detrimental to those failing to attend school, it can have broader implications. For example, students with regular attendance suffer reduced motivation as their teachers repeat work for those students who have missed lessons (Sahin, Arseven, & Kiliç, 2016).

Henry (2007) identified that absenteeism is affected by SES and parental education. Corroborating these findings, Balkis et al. (2016) and Rotham (2001) found that students from low SES backgrounds had higher rates of absenteeism that were often impacted by family issues, such as poverty, domestic violence, parents working long hours, and/or unsupportive parents due to their own unfavourable school experiences. It is a culmination of these factors that play a significant role in absenteeism leading to high student dropout from schooling (Sahin et. al., 2016).

Context of the study

The school discussed in this paper is a new government school situated in an outer metropolitan area within an Australian state. Given its location, it generally attracts students from low SES backgrounds, including recent migrants and refugees. Approximately 50% of students have English as an additional language or a dialect with 7% being Aboriginal and Torres Strait Islanders. The school offers a number of specialist programs in particular specialist mathematics, and STEM. While attendance has been improving slowly due to the employment of attendance officers and a SMS messaging system to parents, absenteeism remains a major concern. Hence, this study was initiated by the school's leadership team who were keen to gain insights around the rates of absenteeism of students in relation to various subjects. As with most other schools, considerable data are collected for various reports, however rarely are detailed analyses undertaken to identify patterns that might inform school practices.

The context of the school is truly unique comprising an all-female campus sitting alongside a co-educational campus. In this manner, it overcomes major issues often associated with gender and low SES studies where comparisons are completed across schools e.g., a co-educational school and a single-sex school. Inclusion of different schools introduces confounding variables, such as teacher variation, leadership, and school-based policies into the analyses. Given that both campuses coexist within the one school, comparisons across the two campuses are possible while confounding variables remain constant. In this way it was possible to gain a sense of absenteeism generally but more importantly facilitate comparisons across female students enrolled in STEM-related and non-STEM-related subjects across the two campuses.

Research methods

The study applied a quantitative case study approach (Denscombe, 2004) to identify patterns and trends in female student data. This approach was selected as a means of investigating the data across a number of variables, including subject selection. The initial spreadsheet contained subject selections for each semester, days absent for each school team, and student achievement for each school term for a single cohort of female from Year 10 (2014) to Year 12 (2016). This paper focuses on the results for the female student data in relation to subject participation (STEM versus non-STEM) and absenteeism, which was of particular interest to the leadership team in the school.

Research questions

Data were interrogated to address two main research questions with a number of sub-components:

1. What are the differences in the rates of participation in STEM subjects among female students?
    a. Does the percentage of STEM subjects studied differ by year level?
    b. Does the percentage of STEM subjects studied by year in each campus?
    c. Does the percentage of STEM subjects studied differ between campuses by year level?

2. What are the differences in the rates of absenteeism among female students in relation to STEM versus non-STEM subjects?
    a. Are there differences in absenteeism between females majoring in STEM vs non-STEM subjects for different year levels?
    b. Are there differences in absenteeism for females across campuses?
    c. Are there differences in absenteeism for females majoring in STEM vs non-STEM subjects across campuses by year levels?

STEM participation

While the researchers acknowledge that defining STEM can be complex, a traditional definition comprising the core disciplines of science, technology, engineering and mathematics was adopted. This interpretation aligned with the subject classifications utilised by the majority of secondary schools in Australia producing the following subject delineations (Table 1). Subjects not identified below were considered as non-STEM.

Table 1: Categorisation of STEM subjects

STEM – Year 10	STEM – Years 11 & 12
Mathematics	Biology
Science	Chemistry
Workshop technology (Design and Technology)	Physics
	Mathematics
	Mathematics applications
	Numeracy for work and the community
	Mathematics D
	Mathematics specialisms (Year 12)

Research sample

The data summarised in the Table 2 represents a single cohort of female students (n = 95) and the numbers of females attending each of the two campuses.

Table 2: Overview of research sample

Variable	*n*
Total number of students	**95**
co-educational campus	40
all-female campus	54
(removed from analysis)	1

Analyses of the data
Prior to analysis, absence rates were calculated for each student as the proportion of total lessons missed per subject. Normality of the data was assessed using boxplots, descriptive statistics and traditional test procedures, such as the Shapiro-Wilk test (Shapiro & Wilk, 1965). Normality of the absence rate data was tested across all students collectively as well as for all stratified subsets of the data based on student campus, gender, and year level. In each case, the data were found to be non-parametric in nature and as such, non-parametric analysis procedures were performed on the data over traditional parametric approaches, such as the *t*-test and ANOVA procedures. These parametric procedures become unreliable and untrustworthy when the assumptions of normality are violated.

In analysing the absence rates, the Mann-Whitney U test (Sheskin, 2011) was applied to test for a significant difference between STEM and non-STEM subjects as well as between the all-female and co-educational campuses. Additionally, the Friedman test (Sheskin, 2011) was applied to detect statistically significant changes in the proportion of STEM subjects studied by year level and campus. The Kruskal-Wallis test (Sheskin, 2011) was then used for detecting differences in the uptake of STEM subjects between female students at the co-educational and at the all-female campus for each subject year level. Each of these statistical testing procedures was necessary to address the unique research questions while appropriately reflecting the non-parametric nature of the data. In particular, the Mann-Whitney U test is suitable for detecting significant differences between two groups while the Kruskal-Wallis test is appropriate for more than two groups of data. Similarly, the Friedman test is designed to test for significant changes when the data contains more than two groups with repeated measurements over time, such as the proportion of STEM subjects undertaken by year level.

To further explore the nature of the relationship between absence rates and STEM subjects, a multiple regression was performed using absence rates as the dependent variable and course STEM status, subject year level, and campus as the predictor variables. This analysis quantified the impact of individual predictor variables on absence rates while controlling for other variables in the data, thereby providing a detailed insight into the relationship between absence rates and STEM subjects.

All quantitative data analyses were performed using R, version 3.4.4 (R Core Team, 2018).

Results and discussion

Within this section, results are presented and discussed in relation to the two Research Questions around the two key foci of participation and rates of absenteeism.

Female student participation in STEM

Research Question 1: *What are the differences in the rates of participation in STEM subjects among female students?*

The subjects selected by each student were categorised as either STEM or non-STEM, with the proportion of STEM subjects studied across each year calculated for each student in the data set. The uptake of STEM subjects was then analysed by year level and campus. Initially, data were explored to identify differences in the pattern of female participation in STEM subjects overall. A visualisation of these data can be seen in the box plot in Figure 1, which demonstrates the spread and measures of central tendency. Due to the non-parametric nature of these data, the Friedman test was applied. Results were significant (χ^2 = 45.925, df = 2, p < 0.001), indicating that the percentage of STEM subjects studied differed significantly by subject year level.

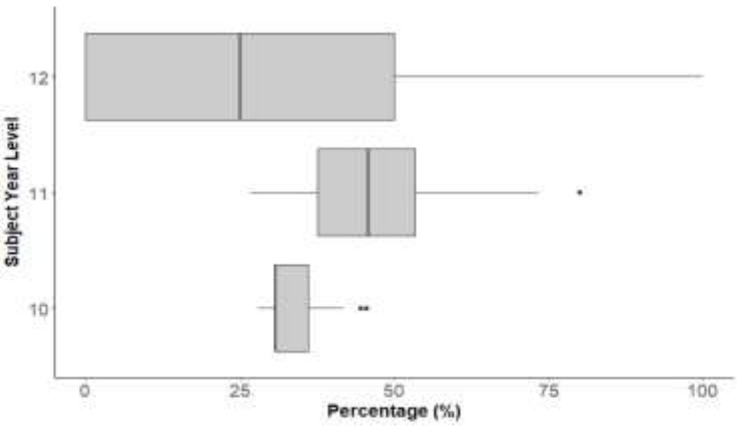

Figure 1: STEM subjects by year level

In order to identify exactly where these differences lay, a post hoc analysis was undertaken indicating that the percentage of STEM subjects studied in Year 11 was significantly greater than Years 10 and Year 12 with no significant differences emerging for Years 10 and 12. These results are expected given that it is compulsory for all Year 10 students to undertake the subjects identified as STEM with the first opportunity to self-select subjects arising in Year 11. It is likely that most students will continue with subjects from Years 11 and 12 except in rare circumstances, such as failure in a subject in Year 11.

In terms of campuses, the distribution of the female data across the co-educational and all-female campus is provided in Figure 2, with each analysed separately.

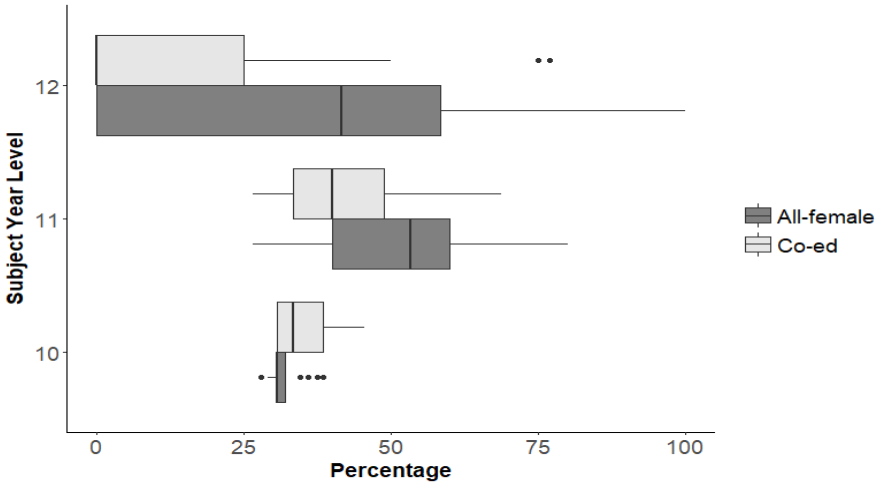

Figure 2: STEM subjects by year level and campus

In terms of the co-educational campus, there was a significant difference in the percentage of STEM subjects studied by year (χ^2 = 31.4, df = 2, p < 0.001). In particular, the percentage of STEM subjects studied in Year 11 was significantly greater than in Year 10 and Year 12 (p < 0.001) so aligns with the opportunity for students to select subjects of interest in Year 11. However, a further finding was that the percentage of STEM subjects studied in Year 10 was significantly greater than in Year 12 (p < 0.001). This suggests that students at the co-educational campus are dropping STEM subjects in Year 12 in favour of non-STEM subjects.

At the all-female campus, a significant difference in the percentage of STEM subjects studied by year (χ^2 = 23.507, df = 2, p < 0.001) was also identified. This too highlighted that the percentage of STEM subjects studied is significantly greater in Year 11 than in Year 10 and Year 12 (p < 0.001). However, no significant difference emerged between Year 10 and Year 12 (p = 0.6313) at the all-female campus. These results appear to fit with the ability of students to select their own subjects at Year 11 and then continue with them into Year 12.

Finally, data were interrogated to test whether there was a campus effect. In order to detect significant differences in the percentage of STEM subjects studied by year level, the Mann-Whitney test was applied. The results indicated that the proportion of STEM subjects in Year 10 differed significantly between the co-educational and all-female campuses (W = 1562, p < 0.001). In particular, the proportion of STEM subjects selected was significantly greater for Year 10 females at the co-educational campus than at the all-female campus. Interpreting this is somewhat difficult but likely explained by the apparent opportunity for students in both campuses to select the number of subjects studied for each semester. For example, at the all-female campus 70% of students studied 26 subjects in total across Year 10 compared to only 53.7% at the co-educational campus. In contrast, 33.3% of students at the co-educational campus studied 25 subjects in Year 10 compared to only 5% of students at the all-female campus.

Similarly, the proportion of STEM subjects studied in Year 11 differed significantly between campuses (W = 732, p = 0.0076), with students at the all-female campus selecting a significantly greater percentage of STEM subjects than female students at the co-educational campus. This raises the question as to what factors may be operating here to make STEM more palatable for these particular female students.

In terms of Year 12, the percentage of STEM subjects studied by female students is significantly higher at the all-female campus than at the co-educational campus (W = 671, $p = 0.0011$). This result links to Year 11 in that once students have opted STEM subjects in Year 11 at the all-female campus they are likely to continue on with them into Year 12.

Hence, these results demonstrate that there is a campus effect evident in relation to female participation in STEM subjects. Students at the all-female campus select more STEM subjects in Years 11 and 12 than their female peers attending the co-educational campus.

Female student rates of absenteeism

Research Question 2: *What are the differences in rates of absenteeism among female students in relation to STEM versus non-STEM subjects?*

Prior to analysis, absence rates for each student were calculated as the proportion of lessons missed for each subject over the course of a year. The overall findings are presented in the box plot in Figure 3.

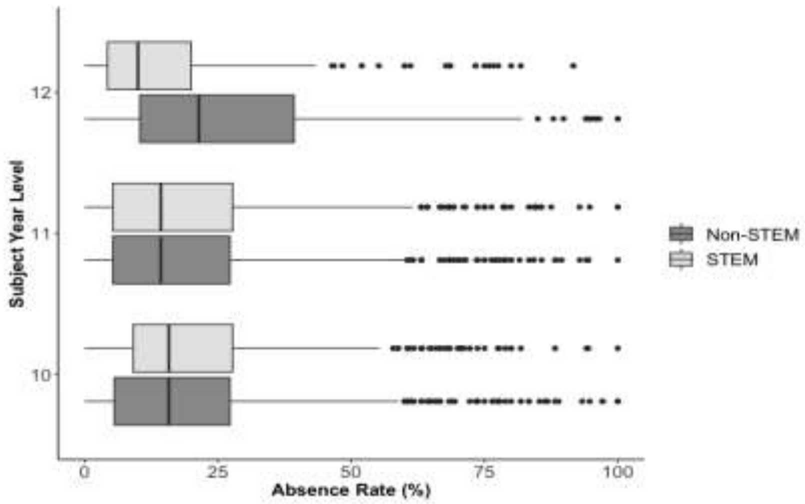

Figure 3: Rates of absences overall

Note: campus has not been taken into consideration for the above figure. Rather the focus here is on absence rates overall, with a separate analysis by campus to follow.

The Mann-Whitney test was applied to compare absence rates across STEM and non-STEM subjects over all year levels, then separately by each year level. A summary of these analyses is provided in Table 3. The first key point to note is the significant difference overall across all year levels in relation to absence rates and STEM versus non-STEM subjects ($p < 0.001$). In terms of Year 10 female students, a significant difference was identified ($p < 0.05$). This related to the spread of the data with fewer absences identified for some students undertaking non-STEM subjects. These results might be expected given that undertaking mathematics and science subjects are compulsory in Year 10 so that female students who are struggling or not as engaged may choose to refrain from attending school on days with multiple lessons in these STEM subjects.

Results for Year 12 female students are highly significant ($p < 0.001$) with higher absence rates identified for students undertaking non-STEM subjects compared to STEM subjects. It might be expected that given the high accountability of Year 12 for all students, absence rates might be minimised regardless of the subject being undertaken. Yet, these results indicate that female students majoring in non-STEM subjects will have a higher absence rate than those students completing STEM subjects. This raises a number of questions: *Does this say something about the nature of STEM subjects compared to other subjects? Does this indicate something about the perseverance of students likely to major in STEM subjects?* Either way, there are interesting questions worthy of further investigation.

Table 3: Comparison of STEM versus non-STEM subjects across all students

	STEM		Non-STEM		
Year Level	**Median**	**IQR**	**Median**	**IQR**	***p*-value**
Overall	14.3	5.6 – 26.7	15.8	6.3 – 30.0	< 0.001*
Year 10	15.8	9.1 – 27.8	15.8	5.6 – 27.3	0.0088*
Year 11	14.3	5.3 – 27.8	14.3	5.3 – 27.3	0.8580
Year 12	10.0	4.3 – 20.0	21.5	10.4 – 39.3	< 0.001*

* indicates a significant difference exists between STEM and non-STEM subjects (p < 0.05).

Further analysis of these data using a Mann-Whitney test identified a campus effect regarding student absence, with students at the all-female campus having significantly lower rates of absenteeism across all year levels together ($p < 0.001$). As demonstrated in Figure 4, there is less of a spread around absenteeism in the all-female campus when compared to the co-educational campus.

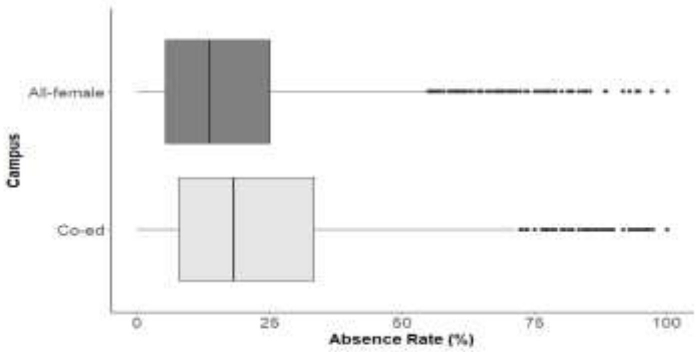

Figure 4: Absence rates by campus

Mann-Whitney tests were applied to detect differences between campuses by each year level. As shown by the spread of the data in Figure 5, clear differences were evident. The results indicated that at each year level, absence rates were significantly greater for females at the co-educational campus than at the all-female campus ($p < 0.001$).

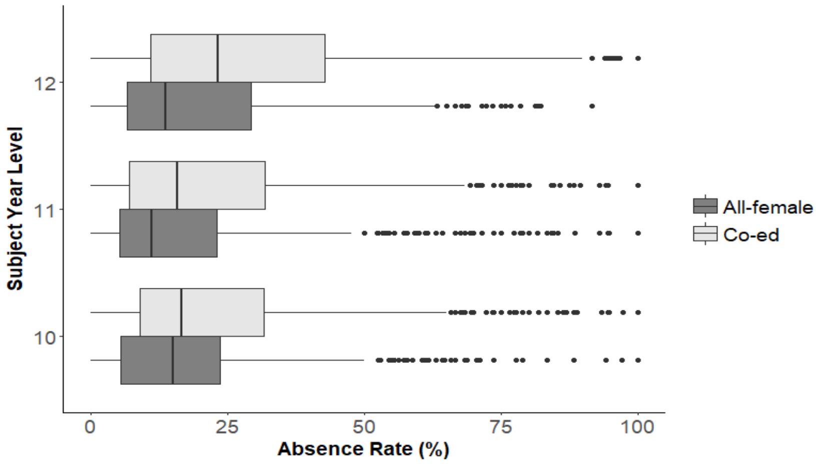

Figure 5: Absence rates by campus and year level

A final analysis was undertaken using a Mann-Whitney test to explore differences in the rates of absenteeism for females majoring in STEM versus non-STEM subjects across campuses and year levels. In relation to the all-female campus (Table 4), absence rates were significantly higher in STEM subjects in Year 10 than in non-STEM subjects ($p < 0.01$). While the overall difference in typical rates of absenteeism between STEM and non-STEM subjects at the all-female campus is small, with an absolute difference of 1.5%, these results suggest that students doing the compulsory STEM subjects are more likely to be absent for these lessons than non-STEM subjects.

Table 4: All-female campus STEM status by year level

	STEM		Non-STEM		
Year Level	**Median**	**IQR**	**Median**	**IQR**	***p*-value**
Overall	13.2	5.3 – 23.5	14.3	5.3 – 25.0	0.1462
Year 10	15.8	9.1 – 26.3	14.3	5.3 – 22.2	0.0029*
Year 11	11.3	5.3 – 23.8	10.5	5.0 – 22.5	0.3719
Year 12	10.0	3.8 – 17.2	18.6	8.3 – 35.5	< 0.001*

* indicates a significant difference exists between STEM and non-STEM subjects

While no significant differences occurred in Year 11, the converse occurred in Year 12 with a higher absence rate identified for students enrolled in non-STEM subjects compared to STEM subjects. As has been discussed previously, subject status as a variable appears to impact rates of absenteeism even at a Year 12 level with greater absences likely by students undertaking non-STEM subjects.

At the co-educational campus (Table 5), absence rates are significantly different overall between STEM and non-STEM subjects ($p = 0.0107$). While no significant differences between the two groupings of subjects were evident for Years 10 and 11, the Year 12 findings were highly significant ($p < 0.001$). Absence rates for these final year students were higher among non-STEM subjects than STEM subjects. In this regard, results are the same as those for the all-female campus.

Table 5: Co-educational campus STEM status by year level

	STEM		Non-STEM		
Year Level	**Median**	**IQR**	**Median**	**IQR**	***p*-value**
Overall	16.7	7.1 – 31.6	19.4	9.1 – 34.6	0.0107*
Year 10	17.1	10.0 – 31.6	16.7	5.6 – 31.8	0.7146
Year 11	15.8	7.1 – 35.6	15.8	7.1 – 31.6	0.7661
Year 12	12.9	6.7 – 26.7	25.8	13.3 – 45.2	< 0.001*

* indicates a significant difference exists between STEM and non-STEM subjects

To explore the relationship between absence rates, STEM versus non-STEM status, campus and subject year level further, a multiple regression analysis was applied to the data. This is an effective technique in that it allows for the quantification of the impact of other variables in the data, including subject year level and course STEM status. While the Mann-Whitney significance testing applied previously was able to detect significant effects of subject STEM status, campus, and subject year level, multiple regression extends the analysis to include an estimate of the magnitude of each individual effect while controlling for the effects of other variables.

The results of the multiple regression analysis are shown in Table 6. The F-statistic for this model was 49.73 with 4 and 6,237 degrees of freedom, which was significant ($p < 0.001$) suggesting that the model was better than chance at predicting absence rates of female students. However, the model had an adjusted R-squared value of 0.0303, indicating that subject status, subject year level, campus and gender collectively explained 3.03% of the variance in absence rates among female students. While the predictive power of this model is therefore low, the parameter estimates in the model can be used to gain an insight into the relationship between the predictor variables and absence rates.

Table 6: Multiple regression analyses

Parameter	**B**	**SE B**	**t**	**p-value**
Constant	23.73	0.50	47.64	< 0.001
STEM vs non-STEM	-1.06	0.50	-2.13	0.0334
Year 11 vs Year 10	-0.45	0.53	-0.84	0.4004
Year 12 vs Year 10	4.07	0.69	5.91	< 0.001
All-female vs co-educational campus	-5.75	0.48	-11.89	< 0.001

From the table, the following observations can be made. When controlling for all other predictor variables, mean absence rates:

- Decrease significantly when changing from a non-STEM to a STEM subject ($p = 0.0334$);
- Do not change significantly when changing from Year 10 subjects to Year 11 subjects ($p = 0.4004$);
- Increase significantly when changing from Year 10 to Year 12 subjects ($p < 0.001$); and,
- Decrease significantly when changing from the co-educational to the all-female campus ($p < 0.001$).

Conclusions and relevance to educational policy

These results while representative of one cohort of students provide interesting patterns that address some questions but raise many others. In terms of participation, the percentage of STEM subjects studied differed significantly by subject year level, with a greater proportion of STEM subjects studied in Year 11 than in Years 10 and 12. Hence, there is some attrition away from STEM generally in Year 12 at the school. However, there was also a strong campus effect evident with students at the all-female campus demonstrating a greater uptake of STEM subjects in Years 11 and 12 than their peers at the co-educational campus. *So, why might this be the case given the consistency of many factors (e.g., teachers) across the two campuses?* Exploring these factors requires a detailed case study of the school including leadership, teacher and student interviews along with the collection of observational data (i.e., lessons).

Similarly, the campus effect remained for absenteeism. Students attending the all-female campus had fewer absences than their peers at the co-educational campus. In general, students were likely to have more absences if undertaking non-STEM subjects than if completing STEM subjects. While there was some variation around this depending on the year level, these variations in absenteeism held even in Year 12 where reduced rates of absence might be expected regardless of the subjects being undertaken. However, these findings demonstrated that students undertaking non-STEM subjects typically missed 18.6% of their lessons at the all-female campus compared to 25.8% of lessons at the co-educational campus in Year 12. *Why are these variations in absence evident in relation to subject selection? Furthermore, is this finding unique to this school or is this a widespread occurrence evident in the majority of schools?*

Of particular interest with these findings is that even though the school was located in a low SES area, there were clear differences evident across the campuses. So there is more to absenteeism and participation in STEM versus non-STEM subjects than SES. This raises a number of questions about students' preferences for the all-female campus compared to the co-educational campus but also about the more subtle nuances that may be at play within both campuses. Future research around the factors identified by Kanny et al. (2014) provides a useful starting point in order to explore more deeply the reasons behind the patterns and trends identified in this exploratory study.

In closing, the results emerging from this analysis of a single school data set highlight a number of critical insights around female secondary students and their rates of participation in STEM versus non-STEM subjects along with their rates of absenteeism. What is critical is that research currently available tends to deal with absenteeism generically, rarely moving beyond the numbers of days absent. However, these results suggest that there is a more complex picture that must be understood if we are to address pervading issues around absenteeism in schools, especially in relation to low SES. Rigorous and specific-focused research in this area is required if we are to inform educational policy and develop appropriate strategies that will enhance the opportunities of all our students into the future.

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References

Archer, L., DeWitt, J., Osborne, J., Dillon, J, Willis, B., & Wong, B. (2012). 'Balancing acts': Elementary school girls' negotiations of femininity, achievement, and science. *Science Education, 96*(6), 967–989.

Balkis, M., Arslan, G., & Duru, E. (2016). The school absenteeism among high school students: Contributing factors. *Educational Sciences: Theory and Practice*, *16*(6), 1819–1831.

Bøe, M. V., Henriksen, E. K., Lyons, T. & Schreiner, C. (2011). Participation in science and technology: Young people's achievement-related choices in late-modern societies. *Studies in Science Education, 47*(1), 37–72.

Becker, K., & Park, K. (2011). Effects of integrative approaches among science, technology, engineering, and mathematics (STEM) subjects on students' learning: A preliminary meta-analysis. *Journal of STEM Education, 12* (5-6), 23–37.

Bentley, T., & Cazaly, C. (2015). The shared work of learning: Lifting educational achievement through collaboration. Mitchell Institute research report, 3. Mitchell Institute for Health and Education Policy and the Centre for Strategic Education, Melbourne. Retrieved from http://www.mitchellinstitute.org.au.

Chapman, C., Laird, J., & Kewal-Ramani, A. (2010). *Trends in High School Dropout and Completion Rates in the United States: 1972–2008 (NCES 2011-012)*. National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. Washington, DC. Retrieved from http://nces.ed.gov/pubsearch.

Denscombe, M. (2004). *The good research guide for small scale social research projects* (2nd Edn.). Berkshire, UK: Open University Press.

DeWitt, J., & Archer, L. (2015) .Who aspires to a science career? A comparison of survey responses from primary and secondary school students. *International Journal of Science Education*, 37(13), 2170–2192.

Eccles, J. S. (2009). Who am I and what a I doing with my life? Personal and collective identities as motivators of action. *Educational Psychologist, 44*, 78–89.

Forgasz, H., & Leder, G. (2017). Single-sex versus co-educational schooling and STEM pathways: Final report. Alliance of Girls' School Australasia. Retrived from https://researchmgt.monash.edu/ws/portalfiles/portal/243002962/243002934_oa.pdf.

Fullarton, S. & Ainley, J. (2000). Subject choice by students in Year 12 in Australian secondary schools. LSAY Research Report No. 15. Camberwell, Victoria: ACER.

Gorard, S., & See, B. H. (2009). The impact of socio-economic status on participation and attainment in science. *Studies in Science Education*, 45(1), 93–129.

Hackling, M., Murcia, K., West, J., & Anderson, K. (2013). Optimising STEM education in WA schools. Part 2: Full Research Report. Joondalup, WA: Edith Cowan University.

Henderson, M., Sullivan, A., Anders, J., & Moulton, V. (2017). Social class, gender and ethnic differences in subjects taken at age 14. *The Curriculum Journal*, *29*(3), 298–318.

Henry, K. L. (2007). Who's skipping school: Characteristics of truants in 8th and 10th grade. *Journal of school health*, *77*(1), 29–35

Kanny, M. A., Sax, L. J., & Riggers-Piehl, T. A. (2014). Investigating forty years of STEM research: How explanations for the gender gap have evolved over time. *Journal of Women and Minorities in Science and Engineering, 20*(2), 127-148.

Marginson, S., Tytler, R., Freeman, B., & Roberts, K. (2013). STEM: Country comparisons: International comparisons of science, technology, engineering and mathematics (STEM) education. Final report. Melbourne, Victoria: Australian Council of Learned Academies.

McConney, A., & Perry, L. B. (2010). Science and mathematics achievement in Australia: The role of school socioeconomic composition in educational equity and effectiveness. *International Journal of Science and Mathematics Education*, *8*, 429–452.

National Academies of Sciences, Engineering, & Medicine. (2016). Barriers and opportunities for 2-year and 4-year STEM degrees systemic change to support diverse student pathways. Board on Science Education and Board on Higher Education and the Workforce. Washington, DC: The National Academies Press.

Niu, L. (2017). Family socioeconomic status and choice of STEM major in college: An analysis of a national sample. *College Student Journal*, *51*(2), 218–312.

OECD. (2015). *The ABC of gender equality in education: Aptitude, behaviour, confidence*. PISA, OECD Publishing. Retrieved from http://dx.doi.org/10.1787/9789264229945-en

Office of the Chief Scientist. (2012). Mathematics, engineering and science in the national interest. (2012). Retrieved from http://www.chiefscientist.gov.au/wp-content/uploads/Office-of-the-Chief-Scientist-MES-Report-8-May-2012.pdf

Office of the Chief Scientist. (2016). Australia's STEM workforce: Science, Technology, Engineering and

Mathematics. Retrieved from, http://www.chiefscientist.gov.au/wpcontent/uploads/Australias-STEM-workforce_full-report.pdf

Paige, K., Caldwell, D., Elliott, K., O'Keeffe, L, Osborne, S, Roetman, P., Lloyd, D., Comber, B., & Gosnell, S. (2018). *Fresh water literacies transdisciplinary learning for place and eco justice. Final report.* Adelaide: University of South Australia.

Panizzon, D. (1997). An analysis of the role of peers in supporting female students' choices in science subjects. *Research in Science Education*, *27*(2), 251–271.

Panizzon, D. (2009). Science education in rural areas: Exploring the issues, challenges and future directions. In S. Richie (Ed.), *The world of science education: Handbook of research in Australasia* (pp. 137–162). Netherlands: Sense Publishers.

R Core Team (2018). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. Retrieved from, https://www.R-project.org/.

Rennie, L. J. (2010). Gender still matters in Australian schooling. *International Journal of Gender, Science and Technology*, *2*(1), 100–111.

Rothman, S. (2001). School absence and student background factors: A multilevel analysis. *International Education Journal*, *2*(1), 59–68.

Sahin, S., Arseven, Z., & Kiliç, A. (2016). Causes of student absenteeism and school dropouts. *International Journal of Instruction*, *9*(1), 195–210.

Shapiro, S., & Wilk, M. (1965). An analysis of variance test for normality (complete samples). *Biometrika*, *52*(3/4), 591–611.

Sheskin, D. (2011). *Handbook of Parametric and Nonparametric Statistical Procedures* (5th Ed.) Florida, USA: Chapman & Hall, Boca Rotan.

Skedgell, K., & Kearney, C. A. (2018). Predictors of school absenteeism severity at multiple levels: A classification and regression tree analysis. *Children and Youth Services Review*, *86*, 236–245.

Steinke, J. (2017). Adolescent girls' STEM identity formation and media images of STEM professionals: Considering the influence of contextual cues. *Frontiers in Psychology*, *8*, 716.

STEM Partnerships Forum. (2017). Optimising STEM industry-school partnerships: Inspiring Australia's next generation. Issues paper. Retrieved from: https://docs.education.gov.au/documents/optimising-stem-industry-school-partnerships-inspiring-australias-next-generation-issues

Thomson, S., De Bertoli, L., & Buckley, S. (2013). *PISA 2012: How Australia measures up*. Camberwell, Victoria: Australian Council for Educational Research Ltd.

Tytler, R., Osborne, J., Williams, G., Tytler, K., & Cripps Clark, J. (2008). *Opening up pathways: Engagement in STEM across the primary-secondary school transition*. Melbourne, Victoria: Deakin University.

Xie, Y., Fang, M., & Shauman, K. (2015). STEM education. *Annual Review of Sociology,* 41, 331–357.