Female participation in secondary school physics and mathematical studies in the Northern Territory

Patterns, influences and ways forward

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Disclaimer:

Please note: *The Chief Minister's Round Table of Young Territorians is an independent advisory body. The views expressed in this report are those of the authors and are not necessarily reflective of those of the Office of Youth Affairs or the Northern Territory Government.*

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Abbreviations

ABBREVIATION	DEFINITION
STEM	Science Technology Engineering and Mathematics
NT	Northern Territory
ATAR	Australian Tertiary Admissions Rank

Terms Used in this Report

Stage 2 Subject: The level of subject needed to complete year 12.

Mathematical studies/Intermediate-level mathematics: The standard level of mathematics required to gain admission into engineering and science courses throughout Australian universities.

Note: Mathematical Studies/Intermediate-level Mathematics will be referred to as ‘mathematics’ for the purpose of this report.

Executive Summary

This project aimed to analyse existing gender patterns across enrolments in year 12 physics and intermediate-level mathematics in the Northern Territory (NT) and to investigate reasons for the existing gender disparity.

Quantitative and qualitative data were collected from both primary sources (statistics, surveys and interviews) and secondary sources (journals and government reports).

Research conducted confirms that from 2011 to 2014 there were low female enrolments in science, technology, engineering and mathematics (STEM) subjects. It also identified that when choosing subjects girls are often influenced by cultural stereotypes, perceptions and self-efficacy. Consequently, these findings justify the implementation of targeted campaigns to educate teachers, parents and students about these issues.

It is recommended that the Northern Territory Government:

- acknowledges that the gender disparity in mathematical studies and physics exists in the NT and that this results in significant gender gaps in the NT workforce.
- recommends the NT Board of Studies (BOS) and NT Department of Education (DOE) look into possible reasons that the STEM curricula deters some students, and implements gender literacy education initiatives such as programs run by *Chalk Circle* (www.chalkcircle.org/out-mission/).

- develop community initiatives to encourage girls from primary school through to secondary school to participate in STEM subjects and activities - for example in the disciplines of physics, mathematics and computing, through parent groups such as Northern Territory Council of Government School Organisations (COGSO).
- conduct further research to obtain a more comprehensive understanding of influences on students' enrolment decisions throughout the whole of the NT.

Introduction

Australian women remain under-represented in Science, Technology, Engineering and Mathematics (STEM fields, particularly in the disciplines of mathematics, engineering and computing (Roberts, 2014). This can be linked to the lack of year 12 female enrolments in subjects such as physics and intermediate-level mathematics which leads to fewer female students feeding into tertiary courses relevant to careers in mathematics, engineering and technology (Forgasz, 2006).

Addressing this issue is essential for a number of reasons. Young people's participation in STEM is vital if Australia is to secure its future economic prosperity and it is critical therefore to ensure that our nation does not neglect the human resource capital of females (Australian Industry Group, 2015). Female participation in these fields will ensure greater relevance to the real world applications of scientific work, increased productivity and growth through the strengthened innovation resulting from of heterogeneity. Benefits also include improved social justice and gender equity (Mather et al, 2014).

The majority of existing research concerning Australian year 12 enrolments in mathematics and sciences is limited to the entire population of year 12 students across Australia, or is focused on the student population of the most populated jurisdictions - New South Wales (NSW) and Victoria (VIC) (Forgasz, 2006, NSW Government, 2014, Milburn, 2010).

This focus of this research paper is on the NT as it is an under-researched demographic in regards to issues around female participation in STEM, and may have social and cultural norms that are not as evident in other Australian jurisdictions. On the other hand, it is likely that the NT shares many similarities with its interstate counterparts because the majority of secondary school enrolments in the NT are from urban schools.

Aims and Methods

The main aims of the study reported in this paper are:

- to examine the gender differences in Stage 2 Mathematics and Physics enrolments in the Northern Territory for the period 2011-2014

- to identify the influences which impact on student's enrolment decisions

- to make recommendations to the NT Government in order to assist in the development of relevant policy.

A focus on Stage 2 Physics and Mathematical Studies

Mathematical studies and physics enrolments at a Stage 2 level are explored in this study because it is the year 12 completion of these subjects that results in post-secondary school opportunities in the STEM fields.

Gender disparity is most prevalent in tertiary courses such as engineering and computing. Physics and Mathematical Studies are generally required as pre-requisites for these courses however the advanced level of mathematics, Specialist Mathematics, is considered to be more beneficial even though it is not a pre-requisite (Forgasz, 2006). Students in school often opt to study Mathematical Studies instead of Specialist Mathematics in order to maximise their Australian Tertiary Admissions Rank (ATAR).

Research Methodology

This study reviewed enrolment data for the years 2011 to 2014 from the Board of Studies and school students were consulted through survey distributed in December 2014 to year 9 (105 responses), year 10 (99 responses) and year 11 students (111 responses). Both enrolment and survey data were entered into excel spread sheets; calculations were undertaken and graphs drawn. Semi-structured interviews were also conducted with a total of 12 teachers from senior secondary (11 interviewed) and middle school (1 teacher interviewed) across a range of teaching disciplines.

Discussion/Major findings

Patterns 2011-2014

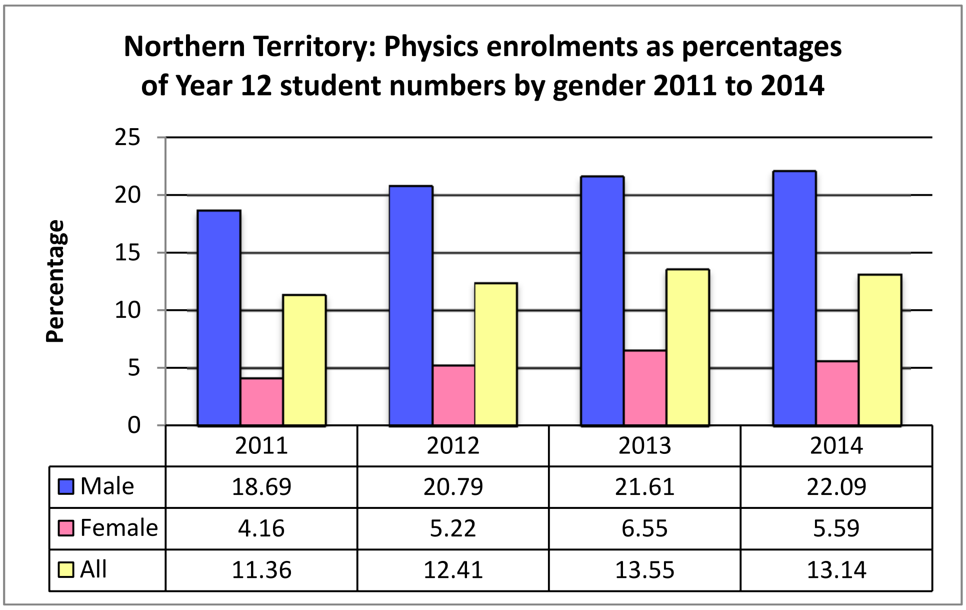
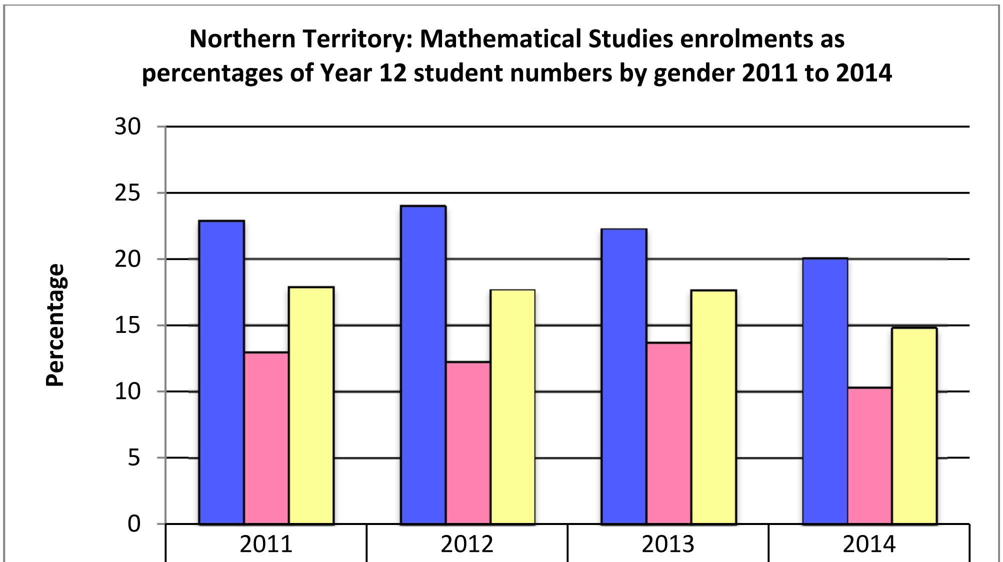


Figure 1: Northern Territory: Physics Enrolments in year 12 intermediate level mathematics subjects expressed as percentages of year 12 cohort size by gender, 2011-2014

Figure 1 indicates that in each year from 2011 to 2014 the percentages of NT male students enrolled in year 12 physics were higher than the percentages of female students. The differences in percentages for male and female enrolments increased slightly from 11.36% to 13.14% during this time frame. The average male:female ratio of students enrolled in physics as a percentage of the cohort was 4:1. This ratio of participation in physics is greater than the overall Australian gender ratio in 2012 which was 3:1 (Kennedy et al, 2014).

Both male and female enrolments as percentages of their respective year 12 numbers increased slightly over the four year period. This is inconsistent with Australian trends which show an overall steady decline in year 12 physics enrolments from the year 1992 to 2012 (Kennedy et al, 2014). In the NT, the increase in year 12 male enrolments was from 18.69% to 22.09% (average growth rate of 5.8 %) and for female enrolments from 4.19% to 6.55% in 2013 and then decreasing to 5.59% in 2014 (average growth rate of 12.65%).



	2011	2012	2013	2014
Male	22.93	24.01	22.3	20.1
Female	13	12.29	13.69	10.35
All	17.92	17.7	17.69	14.81

Figure 2. Northern Territory: Mathematical Studies enrolments as percentages of Year 12 student numbers by gender, 2011 to 2014.

Figure 2 indicates that, in each year, from 2011 to 2014 the percentages of NT male students enrolled in mathematics were higher than the percentages of female students. The differences in percentages for male and female enrolments fluctuated during this time frame from approximately 8% to 12%. The average male to female ratio of students enrolled in mathematical studies as a percentage of the cohort was 2:1. This ratio of participation in mathematics shows a greater disparity when compared to the participation ratio across Australia of 5:4 (Kennedy et al, 2014).

Both male and female enrolments as percentages of their respective year 12 numbers decreased over the four year period. This is consistent with Australia-wide trends (Kennedy et al, 2014). Additionally, it is to be noted that the total number of enrolments in the NT as a percentage of the year 12 cohorts is well below the national average of 27% during this period (Kennedy et al, 2014). In the NT, the decrease in male enrolments was from 22.93% to 20.10% (average growth rate of -12.30%) and for female enrolments from 13% to 10.35% (-6.02%).

Influences

Female interest levels in mathematics and physics

Results from all female survey respondents suggest that 26% are not enrolling in year 12 mathematical studies and physics because they are disinterested. This suggestion is consistent with previous research which has found that school science and mathematics curricula across Australia is failing to attract students' interest, especially female interest (Lyons & Quinn, 2010; Masters, 2006; Tytler et al, 2008). Respondents did not elaborate on the cause of this 'disinterest'. However, past research has attributed this lack of interest to the perceived difficulty of science, a curriculum that follows out-dated practices of teaching and topics that are not relevant to students' needs (Lyons & Quinn, 2010; Osborne & Collins cited in Woods, 2011). All physics teachers interviewed in this study supported this and the majority described the physics curriculum as "tedious" and "dry".

Statements made by respondents' suggesting that females are "not interested" in physics and mathematics could also be interpreted as a biological disinterest or lack of ability which is in contrast to the perception often expressed that males 'biologically' possess this interest and ability. It was noted that some female survey respondents (9%) specifically stated that girls are less likely to enrol in mathematics and physics because their "brains work differently". Does this suggest that they believe that girls are *innately* not as capable or as interested in these subjects? 60% of teachers interviewed echoed this sentiment making statements such as "maths and mathematical thinking is something for the male brain," and "girls naturally have a greater facility for language."

While not dismissing the possible role of biological factors and the hypothesis that girls are innately less spatially intelligent (Maccoby & Jacklin, 1974), it is worth noting that these theories have consistently been disproven (Fennema and Sherman, 1977; Druva-Roush, 1994; Leder, 1980). It is also notable that these theories have often been shown to be out of proportion when reviewed against the limited evidence in favour of these biological hypotheses (Stephen, 2009), and as demonstrated in opinions stated by the teachers.

Furthermore, half of the teachers interviewed who held the 'inherent differences' viewpoint, offered no solution to the problem of the under-representation of females in mathematics and physics. They also stated that they feel no change is necessary because "people who do not have such inclinations should not be forced."

Girls and the perception of difficulty and ability in mathematics and science

Perception of the effort required and the difficulty of physics and mathematics has previously been found to influence students' enrolment choices in these subjects (Havard, 1996; McPhan et al, 2008) and numerous studies, including Watt's (2004) Australian Longitudinal Study which focused on Australian students in years 7 to 11, found that perceptions of the difficulty and effort required were higher for girls than for males across all year levels. Survey data from this study supports these findings as follows: 42% of girls compared to 26% of boys surveyed in year 9,10 and 11 reported that out of all of their subjects, mathematics was the most difficult. Additionally, 10% of year 11 girls stated that girls do not enrol in mathematics and physics because the workload is too demanding. In other words, as found in the Brown (2009) study, girls perceive that the cost and effort required to succeed in these subjects outweighs the benefits. Students take into account their perceptions of difficulty, effort and competence in order to gauge whether or not they have the ability to be successful (McPhan et al, 2008; Lindahl, 2003; Lyons & Quinn, 2010, OECD, 2015).

In this study, all of the mathematics and physics teachers interviewed observed that the girls who did enrol in their classes were confident that they could succeed and generally would be amongst the high achievers. This is in line with findings from the PISA 2012 study which showed that there is a clear positive correlation between a student's self-belief and their interest and achievement in that subject (OECD 2015). Furthermore that study found that girls were far more likely to report being anxious and lacking self-confidence towards mathematics. This could explain the findings in the current study that 42% of girls compared to 11% of boys reported that mathematics was their least favourite subject.

Girls and socialisation

One in 10 survey respondents suggested that the reason for young girls' under-representation in mathematics and physics is due to the existence of gender stereotypes embedded in Australian culture. Indeed, it has been found that traditional notions of typical male and female occupations create significant disincentive for girls to pursue study in STEM disciplines. Stereotyping mathematics, engineering and other STEM fields with masculinity and men, and other careers such as teaching and nursing with femininity and women, translates directly into levels of participation (Kelly, 2014; Barrington, 1999). In this study, it was found that there were no year 9 girls that wanted to pursue a career in engineering, compared with 26% of year 9 boys, demonstrating that such distinct career views can manifest before senior high school.

Schools contribute to the socialisation of young people and teaching practices influence students' interest and willingness to persist with STEM subjects (Brickhouse et al, 2000). Teachers' cultural attitudes concerning gender affect the way they treat male and female students in regards to expectations and encouragement. Therefore, it is alarming that 60% of teachers interviewed in this study still held the ‘inherent differences’ viewpoint, as it is possible that this attitude can negatively impact on female students in their classes. Additionally, in previous studies teachers have been observed as having different expectations towards female and male students despite reporting otherwise (Andersson 2010; Zapata, 2005).

Conclusion

This research project succeeded in providing evidence that there are consistently and significantly less females taking Physics and Mathematical Studies in NT secondary schools. The reasons for this include out-dated curricula, perception of difficulty and a lack of self-belief due to gender stereotypes.

It is clear that a significant gender disparity exists in both Stage 2 Mathematical Studies and Stage 2 Physics in the NT. The average ratio of male:female students enrolled in physics is 4:1 and female participation has decreased over the four year period. On the other hand, female participation in mathematics has increased slightly however the ratio of male to female participation was still unequal at approximately 2:1. This lack of female participation in both subjects is certainly cause for alarm.

There is no single explanation for the gender gap in participation as the underlying reasons operate at multiple levels. In this study it was found that the physics and mathematics curricula are failing to attract female students as they perceive that the difficulty of the subject and the effort required outweighs the benefits, and the prevalence of cultural gender stereotypes strongly influences teacher and student perceptions and behaviour.

Recommendations

Based on this, it is recommended that the Northern Territory Government:

- acknowledges that the gender disparity in mathematical studies and physics exists in the NT and that this results in significant gender gaps in the work force
- recommends that the NT Board of Studies and NT Department of Education, investigate possible reasons that the STEM curricula is deterring students as well as implement education initiatives concerning gender literacy such as programs run by *Chalk Circle* (www.chalkcircle.org/out-mission/)
- develop community initiatives to encourage girls from primary school through to secondary school to participate in STEM subjects and activities - specifically in the disciplines of physics mathematics and computing, for example, through parent groups such as Northern Territory Council of Government School Organisations (COGSO)
- conduct further research to obtain a more comprehensive understanding of influences on students’ enrolment decisions throughout the whole of the NT.

Evaluation

The use of NT enrolment data allows claims to be made in relation to the NT as a whole, however it must be acknowledged that many conclusions were drawn from qualitative primary evidence sourced from only one school. This may mean that these findings are only specific to large urban co-educational schools similar to the that school, and it is probable that the results would be different for single sex schools, rural schools or schools with a lower Index of Community Socio-Economic Advantage (ICSEA) score.

The analysis in this report, *Female participation in secondary school Physics and Mathematical Studies in the Northern Territory 2011-2014: patterns, influences and ways forward,* draws on three different forms of primary sources and the discussion is integrated with 26 current and relevant secondary sources.

In broadening the focus to the whole of the NT, setting the project in the context of the Chief Minister's Round Table of Young Territorians and adhering to ethical principles through maintaining the anonymity of respondents, this report not only contributes to a gap in the existing body of research, but also has the potential to significantly impact on decisions made by the NT Department of Education.

Please note, the one school surveyed has already acted on the findings of this study by introducing an optional year 10 female science class in 2016. Forty-two students have already selected to take that course.

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