STAGNATION, DECLINE AND GENDER DISPARITY IN PARTICIPATION IN NSW HSC MATHEMATICS AND SCIENCE COMBINATIONS

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ABSTRACT

Participation in maths and science has been a longstanding concern in Australia and elsewhere. Historically reviews of participation have led to several campaigns effective in reducing gender disparity by lifting girls' participation. However there has been no recent account of participation in maths and science that specifically examines subject combinations. We report on the proportion of Year 8 students going on to complete mathematics and science subject combination for the New South Wales High School Certificate (HSC) in 2001 to 2011. Participation rates show small declines in the various maths and science combinations possible, however overall these small declines contribute to a substantial decline in the proportion of students undertaking at least one maths and one science subject. In 2001 some 19.7% of boys and 16.8% of girls studied a math/science combination in the HSC however by 2011 only 18.6% of boys and 13.8% of girls studied maths/science. This is equivalent to more than 1000 fewer students studying maths and science in 2011 than in 2001. There is evidence of a growing gender disparity with greater declines among female students. In an era when overall participation has increased; if maths and science shared in this growth we would expect to report rising participation rates. Urgent policy action is needed to redress these trends.

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INTRODUCTION

In education participation numbers are important; they are seen as the most basic indicator of educational progress. In competing economies they are often used as an index of educational strength and are viewed as the strongest predictor of future educational achievement in a country. Recent attention on Australia's declining attainments and rankings in international educational assessments has raised concerns about the educational wellbeing and economic competitiveness of our nation. In particular maths and science have been areas of grave concern (Australian Academy of Science, 2009). Given the high standards Australia has achieved in education (universal participation to year ten; top quartile status on international assessments) it would be easy to assume that focus should be on attainment not participation. However data presented here, and more historically, suggest that in science and mathematics education careful attention should also be paid to participation rates and the policies that govern them. While national curricula and assessment programs now mandate nationally uniform maths and science to year ten, participation in these subjects in senior high school (and therefore also later at university), is influenced by diverse state and territory education policies, personal choice and variations in educational opportunity.

Maths is a cross-disciplinary pillar that enhances university performance across all the sciences (Sadler & Tai, 2009; CMS; BMSA-DEPS; NRC, 2013) and therefore examination of high school maths and science combinations is important. Back in the 1980s Barry Walsh and Warren Mann produced the final STEP (Secondary-Tertiary Education Planning) report, which examined the flow of students from high school to university in Victoria in the late 1970s, with particular focus on students' preparation for further study in Engineering or Science. Their analysis included summary data on mathematics and science subject combinations taken by male and female students as they progressed from Year 11 to Year 12. Their findings, showing declining maths/science participation rates, caused an immediate re-examination of the Victorian secondary curriculum, aimed at increasing the proportions of suitably qualified high school graduates well-prepared for entry into tertiary courses in the above-mentioned fields. Mack (1986;1989) also examined the pattern of maths/science subject combinations taken by males and females at the NSW HSC, however monitoring of participation rates in the years since has focused on examining participation in separate subjects.

The renewed recent concerns regarding the future viability of science and mathematics based professions in Australia have been highlighted in the recent report to the Prime Minister by the Chief Scientist (Office of the Chief Scientist, 2012). In particular there have been concerns over a decline in maths participation and attainment in Australia (Australian Academy of Science, 2009). This has stimulated us to utilise the STEP approach to examine science/maths combinations, because in our view the use of subject combination data is a more satisfactory basis for expressing concern or making predictions about this matter than using enrolments in various levels of mathematics and for individual science subjects. Science and engineering degrees, and others, have requirements for both maths and science study at university and senior secondary school preparation for these degrees is important for the maintenance of standards within them. In particular, the level at which Year 11 and 12 mathematics has been studied by those entering these degrees is critical, since some reasonable familiarity with the concepts, techniques and skills needed to understand algebra and calculus remains a necessary prerequisite for successful pursuit of degree programs in Engineering and most areas of Science.

METHODOLOGY

We present the proportions of participation in various maths and science combinations as a percentage of Year 8 cohorts that go on to study these combinations for the HSC. This is a whole population study, reporting on the total candidature of the NSW HSC. Detailed tables of participation numbers and proportions are available in the technical paper (Mack & Walsh, 2013); trends graphs are presented here.

We use Year 8 cohort numbers as the reference for the proportion of participation because this represents the first common year at secondary school across Australia's states and territories; for this reason it is conventionally used in studies of secondary school participation. We follow the terminology used in the well-known studies by Barrington and Brown (2007) for NSW, 'Advanced' means 3unit/Extension1 or 4unit/Extension2, while 'Intermediate' means Mathematics 2unit. These are the calculus-based mathematics courses in the NSW HSC. The NSW General Maths course, which does not include calculus, is not considered. We examine these maths courses in combination with HSC Physics, Chemistry and Biology courses. While participation in 'Earth and Environmental Sciences' and 'Senior Science' was also examined the numbers were so low they are not reported here. This study is restricted to NSW HSC data. While it is easy to obtain national data on the whole Year 8 cohort, and also on the total national enrolments of recent school leavers in say Engineering degree programs, there is at present no national data base which provides data on the set of subjects chosen by students for high school graduation certificates. In NSW data from the Universities Admissions Centre permit analysis of the whole HSC cohort.

RESULTS AND DISCUSSION

Overall participation rates for male and female students who complete HSC with maths (intermediate or advanced) and at least one science subject are presented in Figure 1. The gender disparity is highly apparent, as is a gradual downward trend over the ten-year period. Boys' total participation in at least one maths and at least one science subject in 2001 was 19.7% and in 2011 18.6%; not a substantial shift. Girls' total participation in 2001 was 16.8% and by 2011 this dropped to 13.8%. A decline is also evident in total participation rates: in 2001 18.3% (15,294 of 83,700) of the corresponding Year 8 cohort went on to study maths plus at least one science, in 2011 this figure was 16.2% (14,251 of 87,800). Thus it is clear that some 1043 fewer students studied a maths/science combination in 2011 despite the fact that the cohort size for that year was larger and higher proportions went on to HSC study. This figure is particularly concerning given national goals to increase maths and science participation at university.

The trends for boys and girls participation in four different combinations are examined, including: 1) Intermediate maths + one science; 2) Advanced maths + one science; 3) Intermediate maths + two or more sciences; and 4) Advanced maths + two or more sciences. See Figures 2a and 2b.

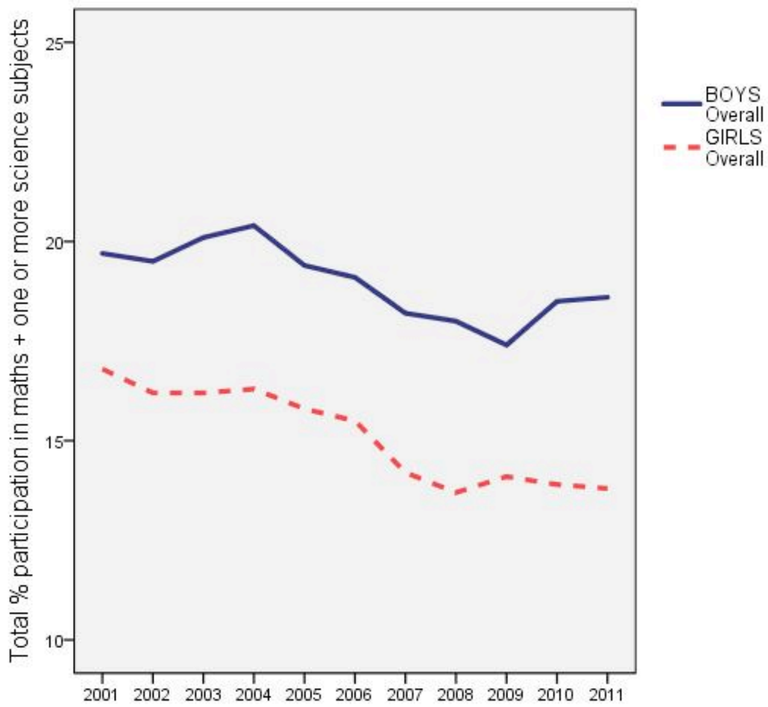

Figure 2: Total participation in HSC maths and science by gender 2001-2011 as a proportion of the corresponding Year 8 cohort.

For both boys and girls there is a decline in the proportions taking a maths and single science combinations. Participation in maths plus two or more sciences is more stable; with an almost discernible rise in boys' participation in advanced maths and two or more sciences since 2009. Girls' intermediate maths and a single science has dwindled the most, from 6.7 percent in 2001 to 4.1 in 2011.

Low proportions of girls go on to study maths and science combinations, with total girls' participation in 2011 at 13.8%. We can compare this with the 16.6% of girls studying English and ancient history combinations and the 13.5% studying English and Community and Family Studies in 2011. If we compare the contemporary maths/science data with that produced by Mack in the mid-1980s an even more disappointing picture of gender disparity is evident. In the previous period, the number of females studying Advanced mathematics, Physics and Chemistry for their HSC was approximately 40% of the corresponding number of males. This proportion has not increased over the subsequent 25 years; in fact it has dwindled to only 34%. Today only 1.5% of girls study this combination, while 4.4% of boys do.

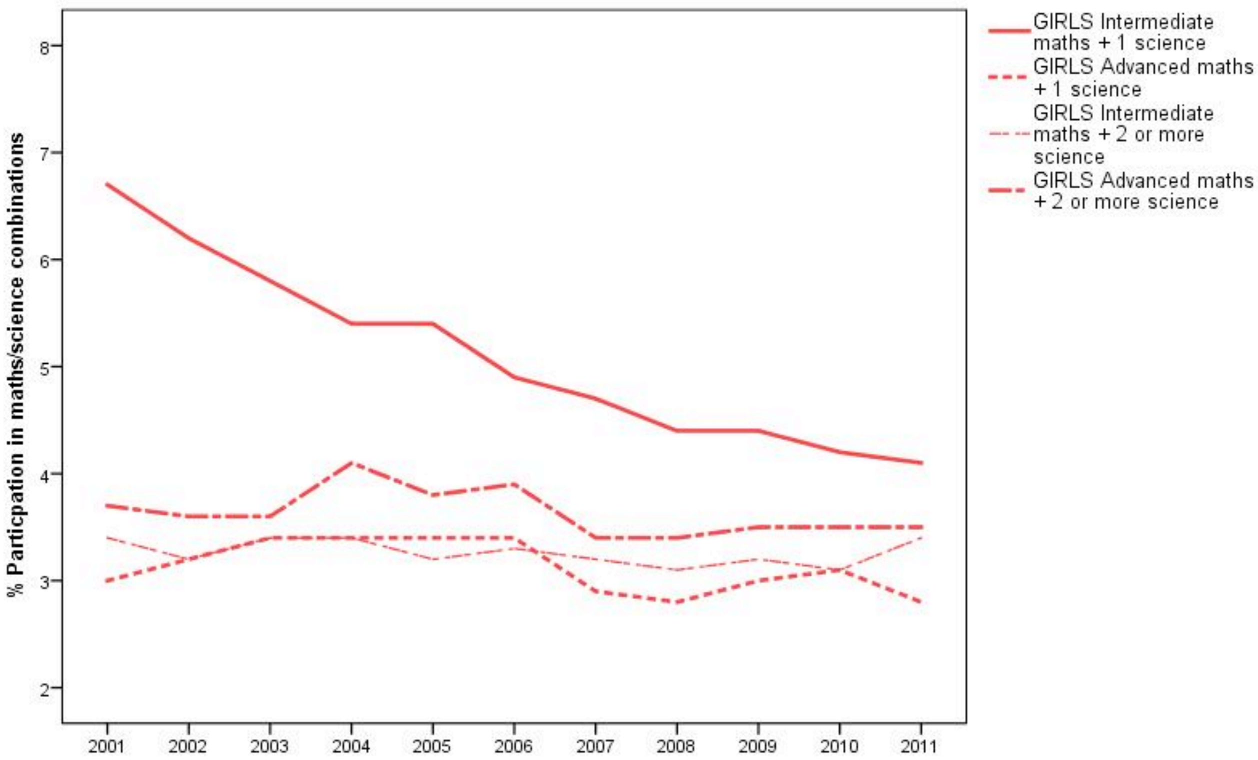

Figure 2a: Girls' participation in science and maths combinations 2001-2011 as a proportion of the corresponding Year 8 cohort.

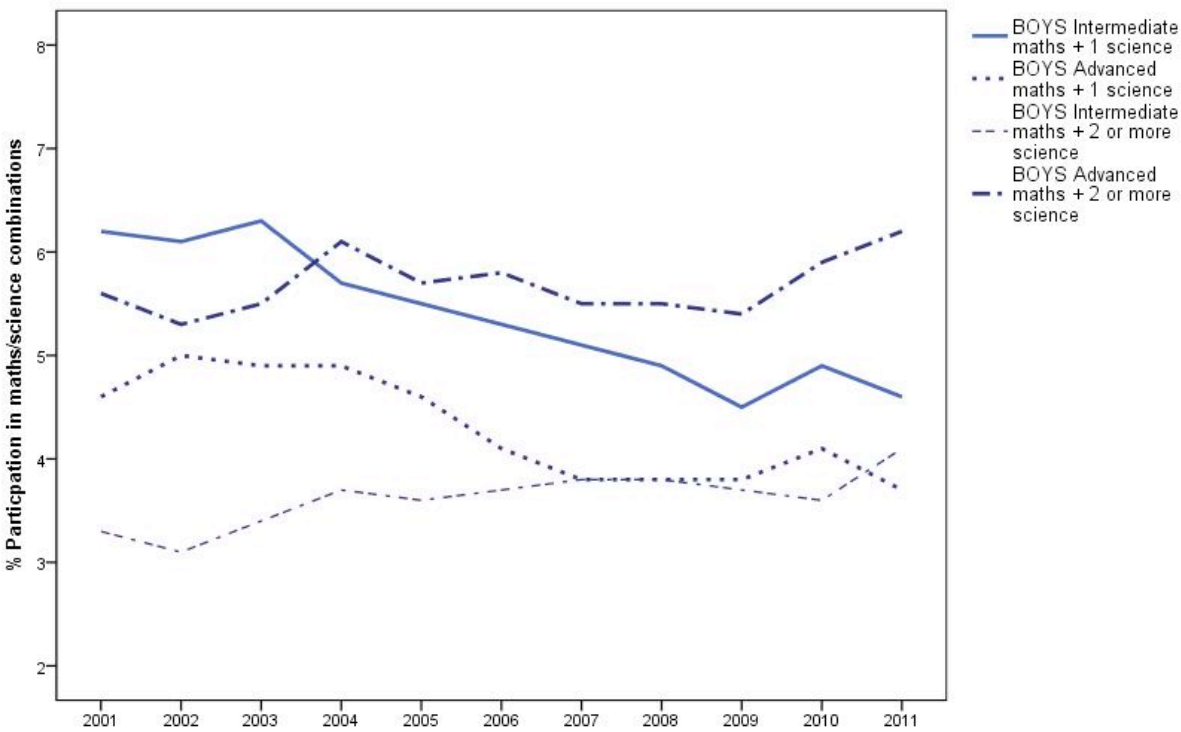

Figure 2b: Boys' participation in science and maths combinations 2001-2011 as a proportion of the corresponding Year 8 cohort.

There are a couple points to consider when examining these trends. First, since 2001 the proportion of Year 8 students going on to HSC has risen from 68.7% to 73.7%. This 5% increase in HSC participation rates might leave us to expect an increase in the proportion of students going on to study math/science combinations. The findings of stagnant boys' participation and declining girls' participation therefore reflect maths and science subjects' failure to participate in the HSC growth. Thus it can be argued that the both the female and male participation figures are disappointing.

Second, much of the decline in girls' participation is evident in numbers in intermediate maths and science combinations. This may be substantially explained by falling participation in intermediate maths as girls' participation fell from 24.78 % in 2001 and to 17.85% by 2011. By contrast there has been slight growth in the proportions of girls taking biology and chemistry over the same period.

Given that currently there are serious predictions that first-world countries will need to have a strong basis in post-industrial employment sectors in order to maintain their standing, and that such sectors are likely to require a workforce which is capable of effectively applying skills and knowledge based upon maths and the sciences, the trends reported here are serious indeed. Further research examining gender and maths and science combinations nationally is needed and should include a program of ongoing monitoring. Currently states and territories have diverse arrangements for high school certificate science and maths study (Wilson, 2013). With much additional work, it would also be possible to track national high school subject participation and performance and secondary-tertiary transition; thus obtaining exact data on the precise preparation level of students entering degree programs. Such work is important for if the trends reported here continue, we may expect a steadily reducing proportion of future HSC cohorts to be studying maths and sciences suitable for entry into many post-secondary courses; with an increasing number unprepared for entry to Engineering or Science courses.

We suggest a three-pronged policy approach to redress the decline. First, policy should reinstate the previously longstanding requirement for students to study at least one mathematics or science subject that was removed at the introduction of the new NSW HSC in 2001. This shift and the increase in alternative subject choices must be seen as factors contributing to the trends. There should also be a nationally consistent policy regarding the inclusion of maths in high school certificates; currently it is not a requirement Victoria and Western Australia; although it is compulsory, with curriculum requirements, in South Australia, Queensland and the Northern Territory. International benchmarks for secondary maths requirements should be considered in setting a national policy.

Secondly, universities should act as levers in lifting participation by re-introducing HSC prerequisites for degree entry. The disappearance of prerequisites has produced anomalies; including students entering science and health degrees without any maths background. Although bridging courses are offered these are often not formally assessed and do not provide a benchmarks equivalent to upper secondary preparation. There has also been a proliferation of specialized service courses offering first year maths to students in varying degrees, with varying math abilities. Universities and professional organisations should collaborate to regulate the standards of skills and knowledge required for entry to professional degrees and to produce more transparent and homogenous standards within degree pathways.

Third, there is a clear need for a public education program promoting the study of science and maths; especially among girls. Such a program should inform teachers, students and parents of the importance of science and maths preparation for later degree study. Ideally this would be integrated with shifts in HSC requirements and university pre-requisites, as suggested above. Furthermore, there remains the challenge of promoting science and maths education across the teaching profession; by ensuring minimum understanding among all teachers; by actively promoting math/science across curricular areas; and by skilling teachers to provide appropriate advice to students. Current degree entry arrangements, and the trends reported here, mean that students entering teacher education are among those with little or no maths and science; we cannot hope to redress the declines, nor address the challenges in STEM education, if this situation persists.

CONCLUSION

This analysis has highlighted the declining female participation and stagnated male participation in intermediate/advanced maths and science combinations of study in NSW. The proportion of girls studying these subject combinations has dwindled since 2001 and there is now a greater gender disparity in maths/sciences participation than there was in the 1980s. Increasing upper secondary participation rates are not reflected in increasing proportions of maths/science study and this reflects a failure to promote maths/science education within increasing upper secondary education. Policies to redress this decline, narrow the gender disparity and lift overall participation are needed. Reverting to the pre-2001 requirement for at least one maths or science subject may go some way to redressing the problem. This study adds to “the [growing] evidence that Australian mathematics and mathematics education are in serious trouble” (Australian Academy of Science, 2009, p1.) with clear repercussions for Australian science. Urgent action is needed, for while Australia stagnates and declines many of our global competitors are on steep upward trajectories.

The countries who out-educate us today will out-compete us tomorrow.

BARACK OBAMA, press conference, Mar. 17, 2009

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REFERENCES

Australian Academy of Science. (2009). *A national strategy for mathematical sciences in Australia*. Retrieved August 6, 2013, from http://www.amsi.org.au/images/stories/downloads/pdfs/general-outreach/National_Maths_Strategy.pdf.

Barrington, F., and P. Brown. "Articulation between secondary mathematics and tertiary education programs." *National Symposium on Mathematics Education for 21st Century Engineers. RMIT University, 7th Dec*. 2007.

CMS; BMSA-DEPS; NRC (2013). Committee on the Mathematical Sciences in 2025; Board on Mathematical Sciences and Their Applications; Division on Engineering and Physical Sciences; National Research Council. *The mathematical sciences in 2025*. Retrieved August 8, 2013, from http://www.nap.edu/catalog.php?record_id=15269#toc.

Mack, J (1986) H.S.C. Participation Rates, *Reflections, 11*(3), 3-6.

Mark, J. (1989) H.S.C. Participation Rates, *Reflections, 14*(3), 4-5.

Mack, J. & Walsh, B. (2013) Mathematics and Science Combinations: NSW HSC 2001-2011 by Gender. Technical paper. Retrieved August 8, 2013, from http://www.maths.usyd.edu.au/u/SMS/MWW2013.pdf.

Office of the Chief Scientist. (2012). *Mathematics, engineering & science in the national interest*. Retrieved August 8, 2013, from http://www.chiefscientist.gov.au/wp-content/uploads/Office-of-the-Chief-Scientist-MES-Report-8-May-2012.pdf.

Sadler, P. & Tai, R. (2007). The two high-school pillars supporting college science. *Science*, *317*(5837), 457.

Wilson, R. (2012). *Make maths mandatory and we'll improve our education rankings*, The Conversation. Retrieved August 8, 2013 ,from http://theconversation.com/make-maths-mandatory-and-well-improve-our-international-education-rankings-11663.