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When is a beer not a beer? An Interstate ODDyssey

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Comparing capacity measures for liquid refreshments between states in Australia can be a confusing enterprise - and one not without a degree of cultural embarrassment, especially when confronted by a grumpy bartender with a particularly parochial sense of state allegiance. Part of the justification for the Federation back in 1901 was to gain consistency in such matters as railway line gauges and mail stamp prices; why then does something as culturally sensitive as beer glass volumes escape the regulatory rigours of nationally consistent standards? This paper will examine some of the quirkier examples of interstate beverage variability in Australia, and then use this to highlight the more serious issue of persistent national inconsistencies in mathematics education.

(A) Beer volumes across Australia – an Interstate Oddyssey

If you have ever entered a licenced establishment in a foreign state and ordered a locally available draught beer in your preferred size of beer glass, you will likely have encountered a conversation with the bartender that runs something like this:

You: I'll have a schooner of Draught, please.
Bar: Sorry, we don't have schooners here, love / mate.
You: Right. Err… what, only middies?
Bar: No middies either.
You: Umm… Okay. Do you serve beer at all?
Bar: 'Course we do. It's a pub.
You: Can I have… err… a glass of beer, then?
Bar: Yep. What size?
You: Ummm… a large beer, thanks.
Bar: That'll be $22.00.
You: For one beer?
Bar: For a jug, yeah.
You: I don't want a jug. I want a schooner.
Bar: Told you, we don't have them.
You: Well, do you have a glass of beer that is smaller than a whole jug?
Bar: Yep. I think you're after a pint.
You: *(through gritted teeth)* Excellent. I'll have a pint. Cheers.
Bar: No worries. Standard or oversized? …
You: You know what? Forget it. I'll have a Scotch.

If you thought getting your head around differences in daylight saving and international time zones across Australia was problematic, spare a thought for the variations we face in standard liquid measure for the sale of amber fluid across our states and territories. The Australian Government's National Measurement Institute inform us that:

> "The sale of beer, stout and ale dispensed from taps must be made by a volume measurement in metric units. Beer, ale and stout must be sold in approved, batch-tested glassware or batch-tested acrylic

> containers marked in millilitres (mL), or litres (L). This includes glass and acrylic jugs. (Note that 'glass' includes other approved materials.)"[1]

So far so good – millilitres and litres will work. However:

> "There are no prescribed sizes for beverage measures for the sale of beer, ale and stout**. Terms such as 'seven', 'middy', 'pot' or 'schooner' do not legally specify a particular size.**"[2]

The problem starts here. It is true that the Australian Government in its wisdom have stipulated that in their 'advertising' publicans are to include the actual metric capacity of the vessels in which they are dispensing the dog's ear. However, just like the disarrayed state of affairs for Australian railway gauges a century and a half ago, it seems that even today we can't agree on a precise name for any given metric volume of cleansing ale between states and territories. Come to think of it, I can't recall ever seeing a beer ad, in a pub or otherwise, that stipulates the fluid measure of your average cold one. The ads have informed me that a case of beer is the accepted denomination of exchange for the task of 'mowing a mate's lawn' - I assume proportionately adjusted according to the area of the lawn in question. However, I don't recall being regaled at the half time break to consider imbibing an ice-cold 285 fluid millilitres.

Thus, for any native New South Welshman or Woman abroad in a sister state, a schooner may not necessarily be a schooner. The unsuspecting Victorian, when visiting a public bar in a northern clime and ordering a 'pot', may find themselves haplessly redirected to the café next door for a nice steaming brew of Earl Grey. The poor South Australian ordering a 'butcher' in an otherwise friendly looking establishment in Collins Street may well be met with a blank stare and polite directions on how to catch the nearest tram to the Queen Victoria Market. It's a problem of national dimension.

It appears not even bottled beer is exempt from voluminar confusion. Knock back a few 'stubbies' in Rockhampton after a hard day's cane-toad hunting, and you'll be comfortably refreshed. Sink a few 'stubbies' after a croc-wrestling tournament in Arnhem Land and they'll be calling in the Flying Doctor and pumping your stomach.

The table below summarises the multifarious state of bevvy-related bafflement facing our nation:

Names of Beer Glasses in Australia – By Metric Capacity (mL)[3] [4]								
Capacity	**NSW**	**ACT**	**VIC**	**QLD**	**SA**	**WA**	**NT**	**TAS**
115 mL	n/a	n/a	Foursie	n/a	n/a	Shetland	n/a	Small beer
140 mL	Pony	n/a	Horse / Pony	Pony / Small Beer	Pony	Pony	n/a	n/a
170 mL	n/a	n/a	Small Glass	n/a	n/a	Bobbie	n/a	Six (ounce)
200 mL	Seven	n/a	Glass	Seven (ounce)	Butcher	Glass	Seven	n/a
225 mL	n/a	n/a	n/a	Glass	n/a	n/a	n/a	Eight
285 mL	Middy	Half Pint / Middy	Pot	Pot	Schooner	Middy	Handle	Ten (ounce) / Pot
350 mL	Schmiddy	n/a	n/a	n/a	n/a	n/a	n/a	n/a
425 mL	Schooner	Schooner	Schooner	Schooner	Pint	Schooner	Schooner	Fifteen / Schooner
570 mL	Pint	Pint	Pint	n/a	Imperial Pint	Pint	Pint	Pint
1140 mL	Jug	Jug	Jug	Jug	Jug	Jug	Jug	Jug
2000 mL	-	-	-	-	-	-	Darwin Stubby	-

[1] Australian Government (2015), *'Guide to the Sale of Alcohol'*, National Measurement Institute, Trade Measurement Division. Lindfierld, NSW. URL: www.measurement.gov.au
[2] Ibid (emphasis mine).
[3] Wikipedia (2015), *'Beer in Australia'*. URL - https://en.wikipedia.org/wiki/Beer_in_Australia#Beer_glasses. Accessed 24 August 2015.
[4] The Aussie Beer Baron (accessed 2015), *'Beer FAQs'*. URL - https://sites.google.com/site/aussiebeerbaron/beerfaq. Accessed 24 August 2015.

The above table warrants some analysis.

Firstly, it appears the only thing we can agree upon is the name of the next-to-largest serving size, the jug. Given that the jug is customarily a serving size to be shared, this probably tells us that we are a social lot who are happy to be ecumenical when it comes down to gathering with like-minded intent. Alternately, it tells us that we're a nation of cheapskates for whom the ability to know exactly what we're paying for when we're purchasing in bulk is paramount.

Secondly, it's interesting to note that both the territories – the Northern and the Australian Capital – don't actually have names for a serving of beer until it's at least 200 mL. In the Northern Territory, this can be easily explained. It's so stinking hot up there just thinking about walking up the driveway to put the wheelie bin out on garbage night would be thirsty work. In the Territory, consuming your favourite cleansing ale in volumes smaller than a fifth of a litre would barely touch the sides, I would imagine. The very existence of the Darwin Stubby is a clear case in point.

The Canberra data set is less easily explained. One might speculate that the apparent disinclination to serve alcohol in small volumes might be linked with the sociological privations of a populace forced to share only 2,358 square kilometres with 226 federal politicians and an estimated 20,000 public servants[5]. (That's one pollie per ten and a half square kilometres when they're all in town, and eight and a half public servants per square kilometre, for those of you who were wondering). Another explanation might be that there's no point serving beer in small glasses in Canberra as this would require too many trips to the bar in an average visit to the pub; there's simply insufficient time when everything shuts at 6:30 pm.

A third observation can be made about New South Wales. It seems that here is the only state in Australia that follows the European peculiarity of serving the amber in, amongst other standard vessel sizes, a glass holding 350 mL. Being a native New South Welshman myself, this actually surprised me. Up until researching this paper I had never heard of the 'schmiddy' and so I invested in some further investigation on this esoteric measure. The name is, obviously, a hint as to its capacity – that is, somewhere in size between a 'schooner' and a 'middy'.

It appears that the schmiddy first made an appearance about ten years ago somewhere around Sydney's CBD or trendy inner-east. Presumably some savvy Balmain or Leichardt publican worked out a way of extracting the same price for 350 mLs that one might otherwise pay for a full schooner on the other side of the Gladesville Bridge. The measure was something of a marketing ruse targeted at the average yuppie who, slapping down his credit card to pick up a bar tab without paying any attention whatsoever to what he's been charged, hasn't noticed he's been short-sleeved to the order of 75 mLs multiplied by his bar count [6]. Thus, the schmiddy appears to be the preferred standard of a fairly limited variety of punter: the kind of fellow who figures that if you drive a car with a German badge, you should jolly-well be ordering a beer with a German-sounding name. The label 'schmiddy' is thus perhaps better re-purposed as a derogatory term for a showy and intellectually compromised individual; a label bestowed upon one who is… well, 75 mLs short of the schooner.

Fourthly, what on earth is going on with the South Australians? Here is a population who clearly feel that their remote location in the nether-regions of the mainland has given them unfettered licence to make up labels that are openly intended to confuse any unwashed punter from the Eastern or Western Seaboards daring to venture down to despoil their pristine southern environs. Thus, go to Adelaide and order a schooner; nope, you'll be served up a middy. Order a pint; nope, you'll wind up sucking on a schooner. Order a pot; you'll likely be told by a frowning publican that he doesn't run that kind of establishment.

Finally, a brief comment on the labels chosen by those friendly Taswegians: 'six', 'eight', 'ten', 'fifteen'. Well, it's good to know they can count in Tasmania, but presumably it's common practice there to use fluid measures of beer to teach basic numeracy in early childhood.

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[5] Commissioner for Public Administration (2012),'ACT Public Service Workforce Profile, 2009-2010'. ACT Chief Minister's Department, Canberra : ACT. URL www.cmd.act.gov.au/__data/assets/pdf_file/0003/294582/wfp1011.pdf. Accessed 26 August 2015.

[6] Izzo, Luis (2005), *'Bring Back the Schooner'*. In *The Sydney Morning Herald*, 7 July, 2005. URL: http://www.smh.com.au/news/heckler/bring-back-the-schooner/2005/07/06/1120329505138.html. Accessed 25 August, 2015.

(B) Australian Jurisdictions for the Regulation of the Sale of Beer Volumes

In Australia, legislation, regulation and licencing for the sale of alcohol are enacted and enforced by state rather than federal authorities. This of course leads to a bewilderingly different application of laws and rules pertaining to alcohol across the country. The respective cases for nationally consistent drinking ages, drink-driving, liquor licencing and servicing laws in Australia have been widely argued by health authorities and lobby groups for decades.

However, the only body which holds national (federal) jurisdiction over regulating liquid measures for alcohol is the Australian Government's National Measurement Institute (NMI). The NMI outlines a number of offenses pertaining to the sale of alcohol in an incorrect measuring instrument resulting in an unfair supply for patrons[7]. These breaches include:

- *"Using a measuring instrument in an unjust manner;*
- *Selling, leasing, hiring or lending a measuring instrument that does not give accurate measure or is not of an approved pattern to be used in selling prescribed alcohols; or*
- *Advertising, offering or exposing beverages for sale at a price determined by a measurement that is not in prescribed units."*[8]

Enforcement of these rules pertaining to the measurement of booze when dispensed by licenced venues is carried out by the NMI's team of 'Trade Measurement Inspectors' who have the ability to seize records and issue non-compliance notices. Think 'Border Force' officers with tape measures and without guns. Nor apparently with a great deal of coercive power, either. Publicans or operators of licenced venues are *advised* to cooperate with visiting Trade Measurement Inspectors… unless, explains the NMI's literature, *"it might tend to incriminate the (proprietor) or expose the (proprietor) to a penalty."*[9] All in all, not terribly compelling stuff.

One need only to look at the recent furore over trading hours in pubs, clubs and licenced venues in the media in New South Wales to illustrate the reality that the real regulatory power over the sale of alcohol lies firmly in the hands of state governments. Accordingly, in keeping with the capricious nature of state government electoral cycles, each of the state legislatures seem to modify their discrete sets of alcohol-related laws with the regularity of the RSL courtesy bus on Bingo Night. It is a constantly shifting legislative jigsaw puzzle.

For example, those Victorians who were disposed to read the Sydney Morning Herald last year when the debate over late-night trading for licensed venues was raging in NSW must have smiled smugly over their Lygon Street chai lattes. They had been through precisely the same brew-ha when the former Brumby government introduced a freeze on late-night liquor licences in 2008 as a measure to curb alcohol-fuelled violence in the city[10]. In Queensland, following close on the heels of the New South Wales debate, the Newman government faced similar pressure to toughen late night trading laws and to review legislation covering penalties on intoxicated patrons, late-night lock outs, moratoriums and precinct-wide licensing conditions[11]. And so on, and so on, in each separate state and territory in Australia. Comparisons across states and territories on booze-related matters are, in short, bewildering.

Without trivialising the seriousness of state-by-state inconsistencies in beer glass measures, the above are serious issues relating to the sale of alcohol. They regularly capture the attention of the media and the concern of wide sections of the community and yet still the states seem unable to arrive at a consensus. When it comes

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7 Australian Government (2015), *'Guide to the Sale of Alcohol'*, National Measurement Institute, Trade Measurement Division. Lindfield, NSW. URL: www.measurement.gov.au

8 Ibid.

9 Australian Government (2015), *'The role of the trade measurement inspector'*, National Measurement Institute, Trade Measurement Division. Lindfierld, NSW. URL: www.measurement.gov.au

10 Barrett, P. (2015), *'Debate brews over liquor licence to drink late in Melbourne'*, in The Sydney Morning Herald, 2 May 2015. URL: http://www.smh.com.au/national/debate-brews-over-liquor-licence-to-drink-late-in-melbourne-20150430-1mx4dx.html#ixzz3kXKrnG53. Accessed 02/09/15.

11 Young, T. (2014), *'The Future of Queensland Liquor Licencing Laws'*, in *Norton Rose Fulbright 'Re:' Magazine*, February 2015. URL: http://www.nortonrosefulbright.com/au/knowledge/publications/113203/the-future-of-queenslands-liquor-licensing-laws?utm_source=Mondaq&utm_medium=syndication&utm_campaign=View-Original. Accessed 02/09/15.

to the matter of regulating the supply of the most widely used drug in Australia, consistency is not high on the national agenda.

(C) The Rationale for Consistent Measurement Standards

The question might well be asked, then, why make a fuss about nationally standard beer glass sizes and names? Surely the provincial quirks of our ale-receptacle nicknames contribute a harmless and somewhat endearing aspect to our national character?

At this point it bears establishing that there are very good reasons for which we need accurate and standardised measures for beverage service in a fair and civilised society. Indeed, there are a number of clear purposes or rationales for which measurement capacities for alcohol are regulated in most modern societies.

1) **Economic Value.** Basically, people like to know they are getting value for what they pay for. This is nothing new, of course; since ancient times, humans have taken the issue of measurement pertaining to the sale of food and alcohol very seriously indeed. Historians tell us that the Ancient Sumerians passed on the art of beer brewing to the Babylonians who, it appears, established the first commercial models and laws for its sale and passed laws regulating the beverage[12]. (Incidentally, the Ancient Babylonian 'Code of Hammurabi' stated, among other things, that publicans who poured a 'short measure' of beer for their patrons were to be summarily drowned. This may be a sobering thought for the Inner-Sydney purveyors of the 'schmiddy'.)

   At a federal level, the Australian Competition and Consumer Commission requires that:

   > *"Big supermarkets and online grocery retailers must display the unit price and the unit of measurement of a grocery item alongside its selling price… Unit prices can appear as per litre, kilogram, 100 millilitres, 100 grams, 10 grams or per item, depending on the type of product."*[13]

   The rationale for national unit pricing laws for grocery items is, of course, that of protection for the consumer. By providing buyers with the price paid per standard metric unit at the point of sale, they are empowered to make clear comparisons. They can ensure they are making a purchasing decision based on mathematically equivalent volumes of goods without having to whip out their smart phone or pocket calculator. However, the ACCC also publishes a long list of exemptions for goods which *do not* have to carry unit prices. You guessed it: 'alcoholic beverages' appears on the exemptions list, squeezed in down the bottom of the list between tobacco and haberdashery.

   Thus, punters making a beverage purchase across the counter even in their own state, let alone in others, can never be sure of the price per unit they are truly paying unless they:
   (a) establish the actual metric capacity of their elected bevvy glass;
   (b) divide the price paid for the beverage by the total capacity in millilitres, and
   (c) multiply by one hundred (assuming comparisons based on a 100 mL standard measure).

   Unfortunately, the execution of this fairly simple mathematical calculation in the moment and at the point of sale will challenge a fairly high percentage of punters in Australia. The fact that this *is* the case is an issue bemoaned in much greater detail later in this paper. Needless to say, making a value comparison between investing in a schooner or middy, a pot or a pint, a round of handles or a jug, will prove well and truly beyond you if you're the poor soul who's up for fifth round in the shout. (Forget the schmiddy altogether – I can tell you now, you're being had.)

2) **Societal Cohesion.** The second reason for which a nationally consistent measurement system for the service of draught beer is desirable is that of societal cohesion. It's bad enough that we live in a country where,

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[12] Mark, J. (2011), *'Beer'*, in *'Ancient History Encylopedia'*, published 1 March, 2011. URL: http://www.ancient.eu/Beer/. Accessed 27/08/2015.

[13] Australian Competition and Consumer Commission (2015), *'Grocery Unit Prices'*. Australian Government : Canberra. URL: http://www.accc.gov.au/consumers/groceries/grocery-unit-prices. Accessed 28/08/15.

when attending interstate conferences or business events, one's geographical origin largely limits one's capacity to discuss football with any degree of historical or technical authority with one's colleagues. Add to that the humiliation of having just ordered a round of '285-ers' when the coves ahead of you in the shout have each just financed rounds of '425-ers' (*"Typical. Stingy bloody New South Welshmen…"*).

Or as per the conversation narrated earlier, you are confronted with a singularly unco-operative bar attendant who is covering the shift of a co-worker who had called off 'sick' and just posted selfies from Thredbo all over Facebook.

Consider the humiliation of the sidelong snickers of regulars who had been waiting desperately for the arrival just such a moment at the expense of a clueless outsider *("Silly bugger asked for a 'middy'. Clearly not from around these parts …"*). Such encounters do little to foster a positive spirit of inter-regional solidarity. It is easy in such circumstances for either side to walk away having drawn the uncharitable conclusion that the residents of the next-door state are either uncultivated philistines or an insular bunch of mean-spirited provincials.

A whole lot of unnecessary embarrassment and social awkwardness could be eradicated if, anywhere in the country, one could confidently waltz into a licenced premises, order a standard bevvy using universally accepted vernacular, nod cursorily at Crusty-Old-Mate in the corner and plonk down to enjoy one's refreshment in self-assured peace and quiet.

3) **Individual and Community Well-being.** The third and final rationale for nationally consistent names and standards for beer glass sizes is associated with the health of the individual and the well-being of the community.

Keeping pace with the amount of alcohol one is imbibing, along with the resultant impact this will have on one's blood-alcohol level and subsequent state of sobriety, is obviously the most important determinant of responsible drinking behaviour. The reasons for this are both obvious and myriad and will not be elaborated for the purposes of this paper. However, we are reminded of *DrinkWise Australia's* clever and mathematically sympathetic campaign slogan that *"the difference between 'drink' and 'drunk' is 'u'"*. Individuals need to be responsible for regulating their own intake of alcohol to avoid the obvious harms of inebriated behaviour to themselves and to others, both on and off the roads. However, to do so they arguably need to be supported by a reliable and consistent system for measuring their intake.

The Australian alcoholic beverage industry's *DrinkWise Australia* organisation provide a useful online 'standard drinks calculator' intended to help young drinkers in particular to keep track of their intake and blood alcohol level. The calculator, qualified by the disclaimer that it is intended for 'educational purposes only', states that:

- In Australia a standard drink refers to 10 grams of alcohol (a nice, round, metric measure) as on average, this is how much alcohol the human body can process in one hour; and
- **Middies** (in NSW) **and pots** (in Queensland and Victoria) **are based on 285 mL pours, and** (for full-strength beer, ie, 4.8% alcohol content) **constitute 1.08 standard drinks**.[14]

Doing the maths, and dealing specifically with full-strength beer, one standard drink therefore constitutes 255 mLs. To stay on the safe side (as you're no doubt aware, many full-strength beers have slightly higher alcoholic content levels, such as 5.2 or 5.4%), let's round that down to 250 mLs. Therefore, assuming this slightly safer definition, that would make a NSW middy 1.14 standard drinks and a schooner (425 mLs) about 1.7 standard drinks.

One thing all the different State and Territories in Australia *do* agree upon is a legal limit of 0.05% Blood Alcohol Concentration (BOC) for fully licenced drivers. Because the body's ability to process and metabolise alcohol varies so significantly between individuals, no online standard drinks calculator worth the weight of

[14] DrinkWise Australia (2015), *'Standard Drinks Calculator'* (Online Resource). URL: https://www.drinkwise.org.au/. Accessed 02/09/15.

its publisher's legal counsel would attempt to provide an accurate blood-alcohol level prediction; nevertheless, we know that as a *general* rule to stay under 0.05:

- Most men can consume two standard drinks in the first hour and one drink each following hour; and
- Most women can consume only one standard drink in the first hour and then one drink each following hour[15].

Therefore, it would be more convenient for the purposes of keeping approximate pace with staying under the legal BOC limit if a standard medium metric Australian beer glass was 250 mLs (approximately 1 standard drink) and a large was 500 mLs (approximately 2 standard drinks).

With the exception of the Darwin Stubbie[16], a general metric tidiness is absent from any of our provincial beer glass taxonomies in Australia, and so the current state of play fails us utterly against this third intention of aiding in the pursuit of community safety and of individual well-being.

(D) Some Other National Inconsistencies: The Need for Consistent Maths Educational Standards in Australia

Well may we bemoan the ways in which our regionally erratic ale measurement idiosyncrasies fail us as a nation. However, Australia has a long history of struggling to attain national uniformity against a wide range of matters of national significance. Since our federation in 1901 from six disparate British colonies, law makers and regulators have striven to gain federal consensus over a broad range of important issues including taxation, democratic franchise and suffrage, road and rail transport, postage, family and criminal law immigration, health standards and educational qualifications.

In many of these areas, the work of the legislative and executive arms of government in gaining national consistency is unfinished. In others, promising starts have been made, albeit with a fair road to travel between national pronouncements and state, regional or local compliance. Attaining national consistency in mathematics education standards and levels of attainment in Australia is one example of the latter.

Jan Thomas, a founding staff member of the Australian Mathematical Sciences Institute, discussed a range of issues in a paper on mathematics education in Australia in 2011. These were associated with the lack of a coordinated national effort to ensure all young Australians received robust and rigorous mathematics teaching at school and at tertiary levels:

> *"Unfortunately… outcomes based education… (resulted in) a fragmented view of mathematics and led to increased state and national testing… Hopefully, mathematics educators and mathematics teachers will be invited to cooperate in producing a national mathematics framework for Australia in the twenty-first century. That is still yet to happen in any significant way."* [17]

At this time – essentially less than five years ago – the lack of a nationally coordinated approach to mathematics education was seen as a significant and potentially intractable problem. International experience shows us that countries who have consistent, focussed curriculum along with high quality teaching expertise are able to generate a critical mass of mathematically literate young people. These are the students who are motivated and capable of taking on advanced levels of high school mathematics and therefore well equipped to move into maths-related undergraduate training and professional careers.

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[15] Royal Automobile Club of Victoria (RACV) (2015), 'How many drinks does it take to get to 0.05 Blood Alcohol Concentration (BAC)?. URL: https://www.racv.com.au/wps/wcm/connect/racv/Internet/auxiliary/faqs/road+safety/drink+driving/. Accessed 04/09/15.

[16] *The modern jug – a rare example of beverage-related interstate consistency – is 2000 mLs (2 Litres) and thus represents 8 standard drinks, a useful volume in a round comprising of 4 or 8 people.*

[17] Thomas, J (2011), *'Maths Matters: Mathematics Education in Australia, 1980-2011'*, p.133. In the Australian Mathematical Society Gazette, Vol. 38, No.3. AMS Inc : Canberra.

It is worth quoting at length here a 2005 report by the International Centre for Excellence in Mathematics (ICE-EM) and the Australian Mathematical Sciences Institute (AMSI). This report compared Year 12 (pre-tertiary) mathematics education between states and territories:

> *"In 2005, nearly all Year 12 mathematics students in Australia fall into one of three categories:*
> *(i) those taking an Elementary subject only (about 100,000 students);*
> *(ii) those taking an Intermediate subject only (about 50,000 students);*
> *(iii) those taking both an Intermediate subject and an Advanced subject (about 25,000 students).*
>
> *Other categories of students have quite small numbers. For example, in some States, a few students take both the Elementary and Intermediate mathematics subjects. A direct comparison of the mathematical content of the seven Intermediate subjects is not in itself very useful, for the following reason: some mathematical topics which are covered in the Intermediate subject in one State are covered in Year 11 mathematics in other States, and vice-versa.*
>
> *Some States regard their Intermediate mathematics subject as a two-year course; others regard their subject as contained within a single year. This situation across Australia is chaotic.*
>
> *Similarly for the Advanced subjects, the situation is even more chaotic. Also, some topics offered within the Advanced subject in one State are offered (perhaps in simpler form) within the Intermediate subject within another State."* [18]

It is also worth pointing out here that, despite the introduction of the Australian Maths Curriculum for students from Foundation to Year 10 Advanced, the situation facing senior (pre-tertiary) mathematics courses in Australia is not substantively different today. If we were to collate these interstate comparisons into a table, the result might be surprisingly familiar to the table we examined earlier:

Pre-Tertiary (Year 11 and 12) Mathematics Course Comparisons: Australia								
Pre-Tertiary Maths Course	**NSW**	**ACT**	**VIC**	**QLD**	**SA**	**WA**	**NT**	**TAS**
Advanced Level Students	Mathematics Extension 2; or Mathematics Extension 1 (A)	Specialist Mathematics (major/major); or Specialist Mathematics (major/minor) (B)	Mathematical Methods AND Specialist Mathematics	Mathematics C	Specialist Mathematics	Mathematical Methods AND Specialist Mathematics	Specialist Mathematics	Mathematics Methods then Mathematics Specialised
Intermediate Level Students	Mathematics	Mathematical Methods OR Mathematical Applications	Mathematics Methods 1,2 then 3,4 OR General Mathematics followed by Further Mathematics	Mathematics B	Mathematical Studies	Mathematics Methods 1,2 then 3,4 OR General Mathematics followed by General Mathematics	Mathematical Studies	General Mathematics OR Mathematics Methods
General Level Students	General Mathematics	General Mathematics	Foundation Mathematics (Y11) OR General Mathematics (Y11) then Further Mathematics (Year 12)	Mathematics A	Mathematical Methods OR Mathematical Applications	Foundation Mathematics (Y11) OR General Mathematics (Y11 and Y12)	Mathematical Methods OR Mathematical Applications	Everyday Maths OR Maths Essential Skills (Foundation) OR Workplace Maths
Other	Non-mandatory Y11/12 level	Non-mandatory Y11/12 level	Non mandatory Y11/12 level	Mandatory for at least 1 semester at Y11 or 12 level	Mandatory for at least 1 semester at Y11 or 12 level	Non mandatory Y11/12 level (C)	Mandatory for at least 1 semester at Y11 or 12 level	Mandatory for at least 'Everyday Maths' course

Notes: **(A)** - The listing of two alternatives for each of NSW and ACT requires some explanation. A strict interpretation of the above "definition" of an A-type student would exclude NSW Mathematics Extension 1 students and ACT Specialist Mathematics (major/minor) students. However, these students undertake studies beyond Intermediate mathematics, and so are to be classified as A-type.

[18] International Centre for Excellence in Mathematics and (ICE-EM) and Australian Mathematical Sciences Institute (AMSI), (2005), *'Comparison of Year 12 Pre-Tertiary Mathematics Subjects, 2004-2005'*. URL: http://maths.org.au/images/stories/downloads/pdfs/education/comp_y12_pretertiary_aus_2004-05.pdf Accessed 08/09/15.

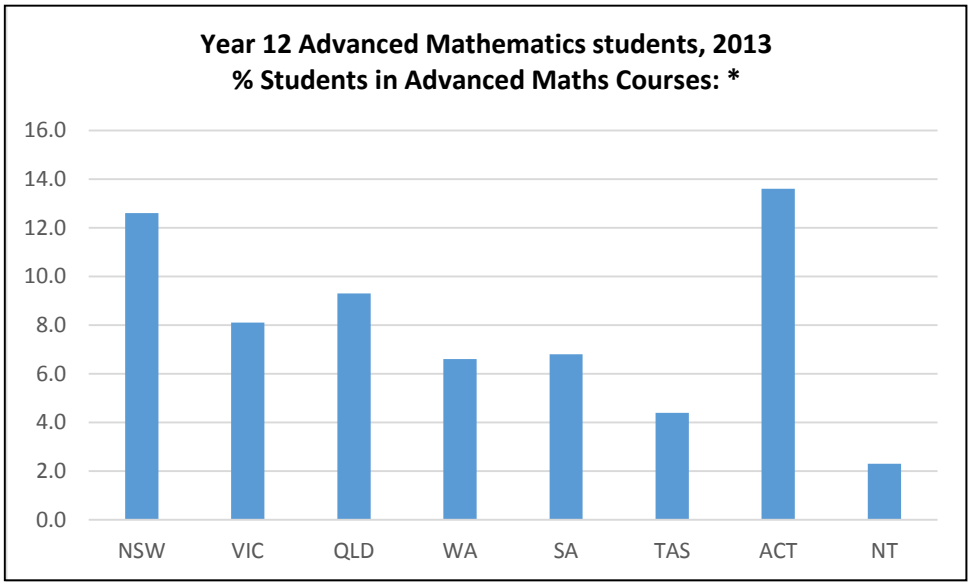
(B) - The term "major" is peculiar to the ACT, meaning that the student takes the whole subject, almost. An ACT student is deemed to complete Specialist Mathematics (major/major) on completion of the first seven of the eight Mathematical Methods "units" offered together with six out of the seven Specialist Mathematics "units". ACT Specialist Mathematics (major/minor) requires completion of the first seven of the eight Mathematical Methods "units" offered together with four out of the seven Specialist Mathematics "units". Thus an ACT student with Specialist Mathematics (major/minor) is an A-type student albeit with less exposure to Advanced Mathematics topics.

(C) - However, a minimum numeracy standard must be met either through an Online Numeracy Assessment (OLNA) or by achieving Band 8 or above in the associated component of numeracy in the Year 9 NAPLAN assessment.

Sources:

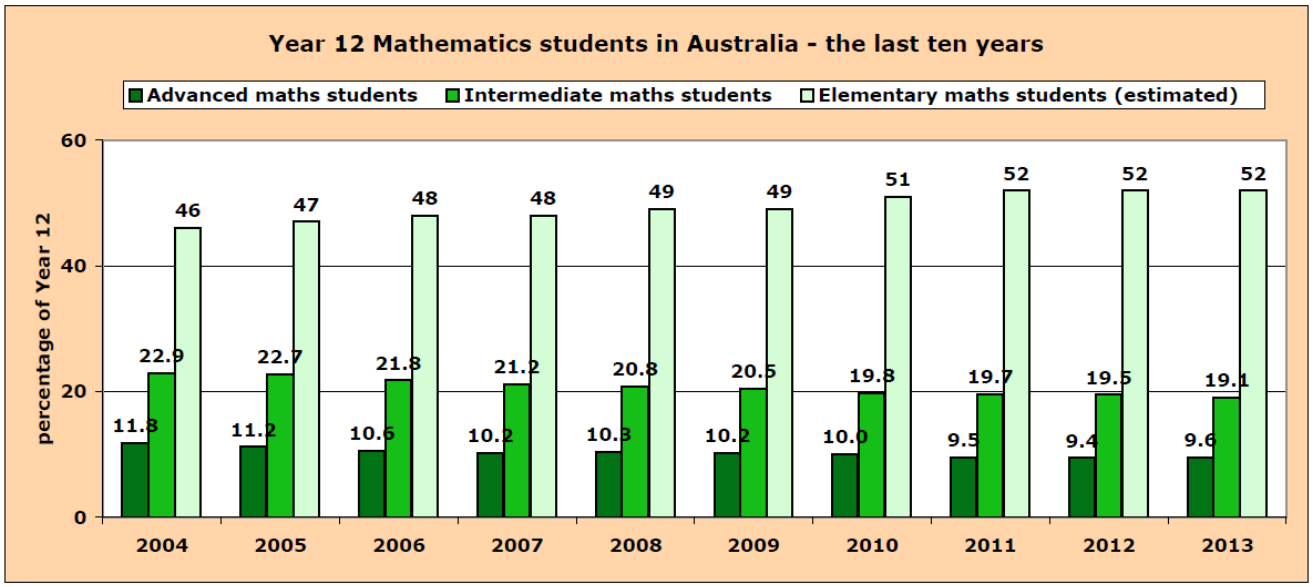
- International Centre for Excellence in Mathematics and (ICE-EM) and Australian Mathematical Sciences Institute (AMSI), (2005), *'Comparison of Year 12 Pre-Tertiary Mathematics Subjects, 2004-2005'*;
- Various State / Territory Curriculum Authorities (online resources) – Accessed 09/09/15; and
- Wilson, L. (2015), 'Push for Mandatory Maths and Science in Year 12' (online article). On www.news.com.au. URL: http://www.news.com.au/lifestyle/parenting/push-for-mandatory-maths-and-science-in-year-12/story-fnggim8m-1227368782277 . Accessed 09/09/15.

Not surprisingly, the above patchwork of senior course offerings across Australia leads to fairly disparate sets of mathematical content, skills and applications, even across similar levels of study. In addition, the extent to which Mathematics is a mandatory component of pre-tertiary school qualifications results in some significant differences in student participation across the states. This is particularly apparent at the advanced levels of mathematics pre-tertiary study:



Source: Australian Mathematical Sciences Group (2015). *Note that calculations are based on state-by-state estimates and definitions, with student numbers rounded to the nearest thousand.*

Overall, the picture facing student numbers and participation rates in advanced and intermediate levels of mathematics – that is, those levels most ideally suiting them to tertiary study in Science, Technology, Engineering and Mathematics (STEM) related professions and fields – is not pretty:



Source: Australian Mathematical Sciences Institute (2014), '*Year 12 Mathematics Student Numbers Update*'. URL: http://amsi.org.au/wp-content/uploads/2014/08/Participation_rates-Y12_2004-14.pdf. Accessed 09/09/15.

The 2006 national review of the mathematical sciences by the Australian Academy of Sciences concluded that:

> *"Australian students are abandoning higher levels of mathematics in favour of elementary levels of mathematics… This is limiting the level of training that can be supplied in undergraduate degree programs such as commerce, education, engineering and science… Mathematicians and statisticians take a long time to train, and need local experts to train them…"* [19]

At this point it is worth asking the essential question: 'Why bother with nationally consistent mathematical standards in education?' Why not simply keep doing what we've previously done? In essence, why is mathematics so important that it warrants a nationally coordinated approach to ensure that all students – regardless of their state, territory, school system or local circumstances - receive mathematical learning experiences based on a consistent and robust curriculum?

Funny you should ask. Coincidentally, just as in the above case study, three key reasons might be echoed:

1) **Economic Value.** Nations whose citizens have a high level of mathematical proficiency create economic value for themselves.

   Cutting edge developments in science, technology, medicine, commerce and management rely increasingly on the work and contributions of mathematical scientists[20], and this has a direct and significant impact on the economy and the value it creates for all Australians. According to a recent estimate, the direct impact of the advanced physical and mathematical sciences contributes 11.2% of the Australian economy, or $145 billion per year, with a further 11.3% ($147 billion) in flow-on benefits[21]:

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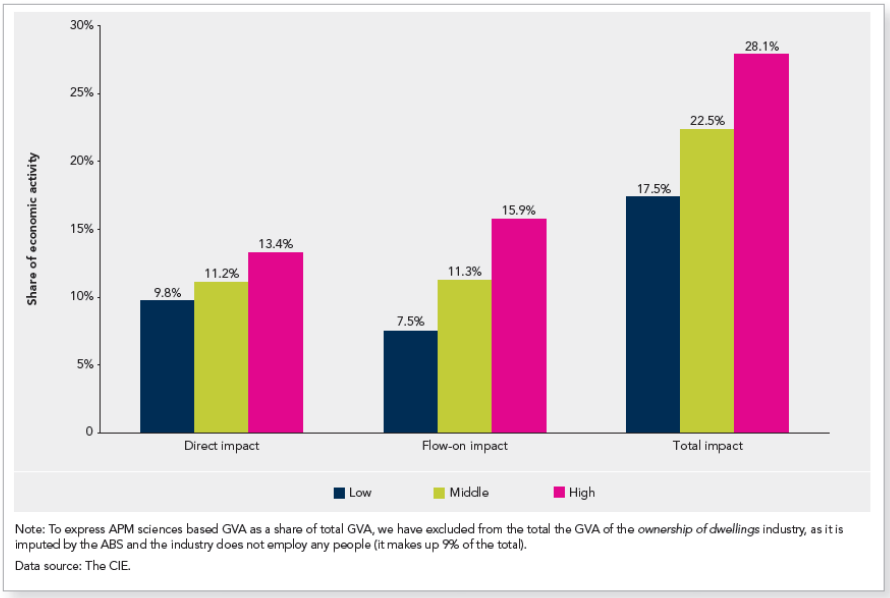
19 Australian Academy of Science (2006), *'Mathematics and Statistics: Critical Skills for Australia's Future. The National Strategic Review of Mathematical Sciences Research in Australia'*, p.9; p.53. AAS/University of Melbourne : Melbourne.

20 Prince, G (2013), *'AMSI Advocacy: Policy Measures in the National Interest'*, p.1. Australian Mathematical Sciences Institute : Melbourne.

21 Australian Mathematical Sciences Institute (2015), *'Discipline Profile of the Mathematical Sciences, 2015'*, p.37. AMSI : Melbourne.

The direct, flow-on and total impacts of the APM sciences on the Australian economy (% share of economic activity, $ billion value added)



Note: To express APM sciences based GVA as a share of total GVA, we have excluded from the total the GVA of the *ownership of dwellings* industry, as it is imputed by the ABS and the industry does not employ any people (it makes up 9% of the total).

Data source: The CIE.

APM: Advanced Mathematical and Physical Sciences
Source: Australian Academy of Science, The importance of advanced physical and mathematical sciences to the Australian economy, 2015, Figure 1, page 1.

Advanced mathematical research in particular has been central to a large number of industries. Business sectors such as finance, transport and computing most often rely on the mathematical sciences which contribute significantly in terms of their gross value add (GVA), as shown in the table below. Furthermore, industries based on multiple advanced physical and mathematical sciences disciplines such as mining, insurance and telecommunications all rely on the application of mathematical research that has been undertaken in the past 20 years [22]:

Sector based on a single core science discipline

Industry		Single core science discipline	Science-based GVA ($ billion)
6221	Banking	Maths	5
7000	Computer System Design and Related Services	Maths	5
4610	Road Freight Transport	Maths	4
1841	Human Pharmaceutical and Medicinal Product Manufacturing	Chemistry	2
6240	Financial Asset Investing	Maths	2
6330	Superannuation Funds	Maths	2
1912	Rigid and Semi-Rigid Polymer Product Manufacturing	Chemistry	2
All other industry classes based on a single core science discipline			25
Total			47
Total (share of total GVA)			3.6%

Note: To express APM sciences based GVA as a share of total GVA, we excluded from the total the GVA of the *ownership of dwellings industry*, as it is imputed by the ABS and the industry does not employ any people (it makes up 9% of the total).

Source: The CIE.

Source: Australian Academy of Science, The importance of advanced physical and mathematical sciences to the Australian economy, 2015, Table 8.1, page 57.

The link between contributions of economic value by the advanced mathematical sciences and consistent national standards in mathematics education, especially at the senior secondary level, is not tenuous. The 2006 AAS National Strategic Review of Mathematical Sciences Research in Australia found that the

22 Australian Mathematical Sciences Institute (2014), *'Discipline Profile of the Mathematical Sciences, 2015'*, p.38. AMSI : Melbourne.

mathematical scientists of most value to Australia both now and in the near future will have, amongst a range of attributes:

- a sound fundamental and deep understanding of mathematical and statistical concepts;
- facility with theoretical analysis;
- experience in mathematical or statistical modelling and in group collaborations; and
- excellent written and oral communication skills. [23]

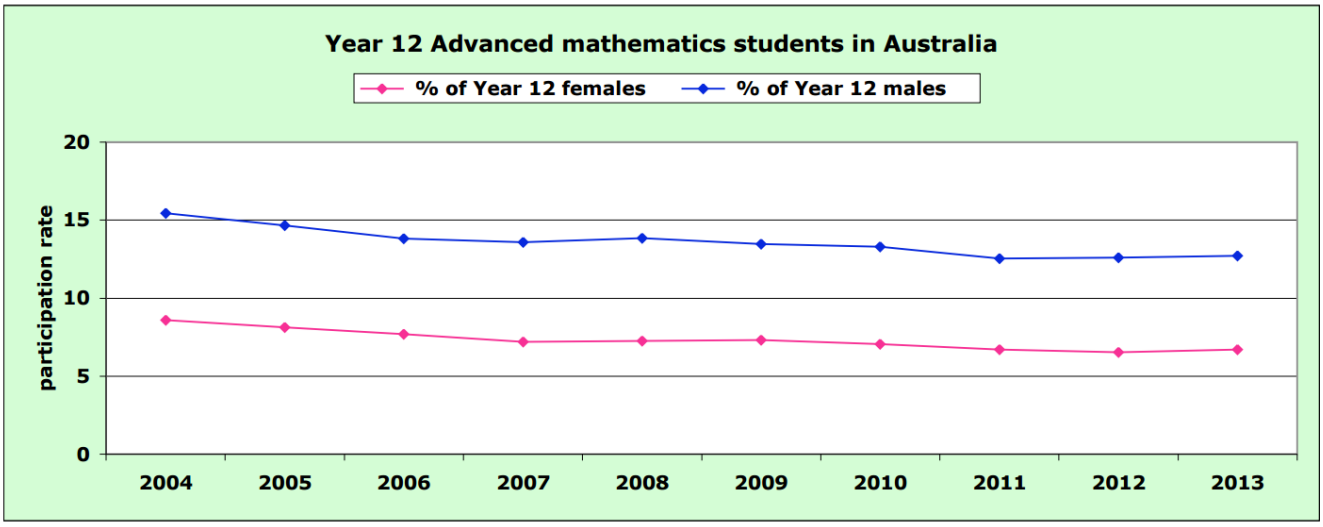
It went on to conclude:

"…only 64% of high schools offer advanced mathematics – and this is likely to contract further in the current climate. Australia is reaching the stage where it is unable to produce the next generation of students with an understanding of fundamental mathematical concepts, problem-solving abilities and training in modern developments to meet projected needs and remain globally competitive." [24]

We need consistency and high standards across all levels of mathematics education, including and perhaps especially at pre-tertiary levels, because not doing so poses a serious threat to Australia's high-end skills capability. To co-opt James Carville's famous pronouncement, "It's the economy, stupid."

2) **Social Cohesion.** We like to think of ourselves as a fairly egalitarian society in Australia that presents opportunities to people on the basis of a 'level playing field'. The ideals of fairness and anti-discrimination are enshrined in much of our legislation and are intrinsic to many of our social institutions, with a few notable exceptions. However, it is well documented - albeit no less alarming - that there is a continued trend of under-representation of young women in mathematics at pre-tertiary and tertiary levels. In turn, women continue to experience much lower rates of representation in mathematically related professions.

In 2013, 6.7% of Australian girls took advanced mathematics subjects compared with 12.7% of boys: [25] [26]



Source: Australian Mathematical Sciences Institute (2014), '*Year 12 Mathematics Student Numbers Update*'. URL: http://amsi.org.au/wp-content/uploads/2014/08/Participation_rates-Y12_2004-14.pdf. Accessed 09/09/15.

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[23] Australian Academy of Science (2006), *'Mathematics and Statistics: Critical Skills for Australia's Future. The National Strategic Review of Mathematical Sciences Research in Australia'*, p.11. AAS/University of Melbourne : Melbourne.

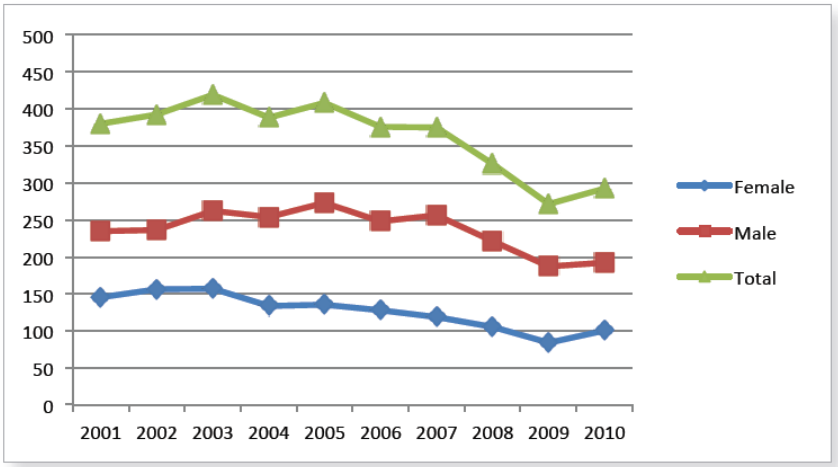
[24] Ibid, p.54.

[25] Barrington, F and Evans, M. (2014), *'Australian Mathematical Sciences Institute Year 12 Mathematics Student Numbers Update'*. URL: http://amsi.org.au/wp-content/uploads/2014/08/Participation_rates-Y12_2004-14.pdf. Accessed 09/09/15.

[26] Note in the above that the overall Advanced rate of 9.6% for 2013 is slightly less than the arithmetic mean of the female and male rates, the reason being that females outnumber males in Year 12.

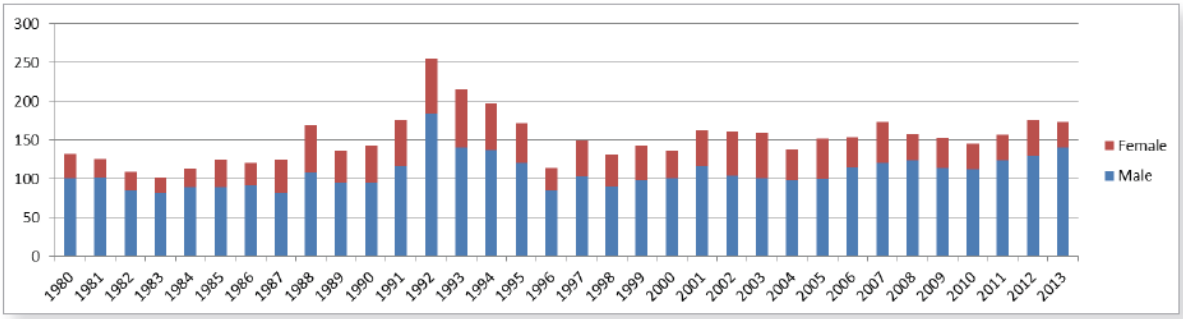
This directly translates into trends for tertiary-level study in Mathematics and Statistics related programs[27]…

Domestic Bachelor (pass) award completions 2001–2010 by gender in the field of education of mathematical sciences*



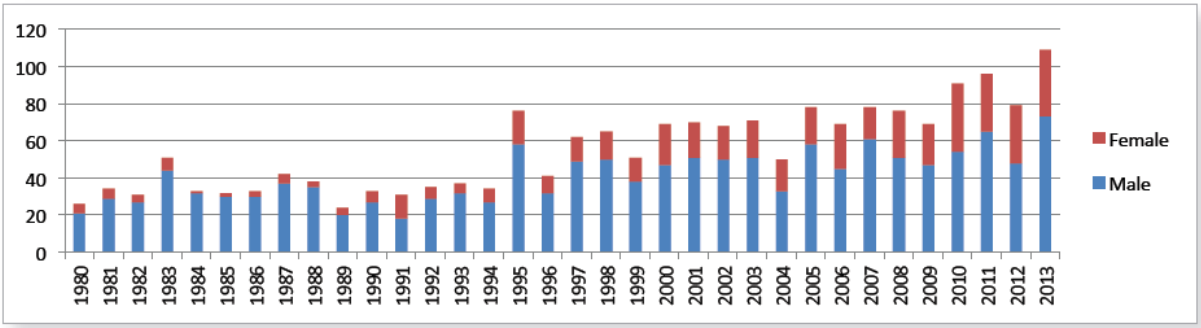
*Data from 29 universities, no data from the University of Melbourne and The University of Queensland included.
Source: Higher Education Data 2001–2010, Department of Education and Training.

Honours completions in the period 1980–2013 by gender



Source: Peter Johnston, Higher Degrees and Honours Bachelor Degrees in mathematics and statistics, data collection provided to AMSI.

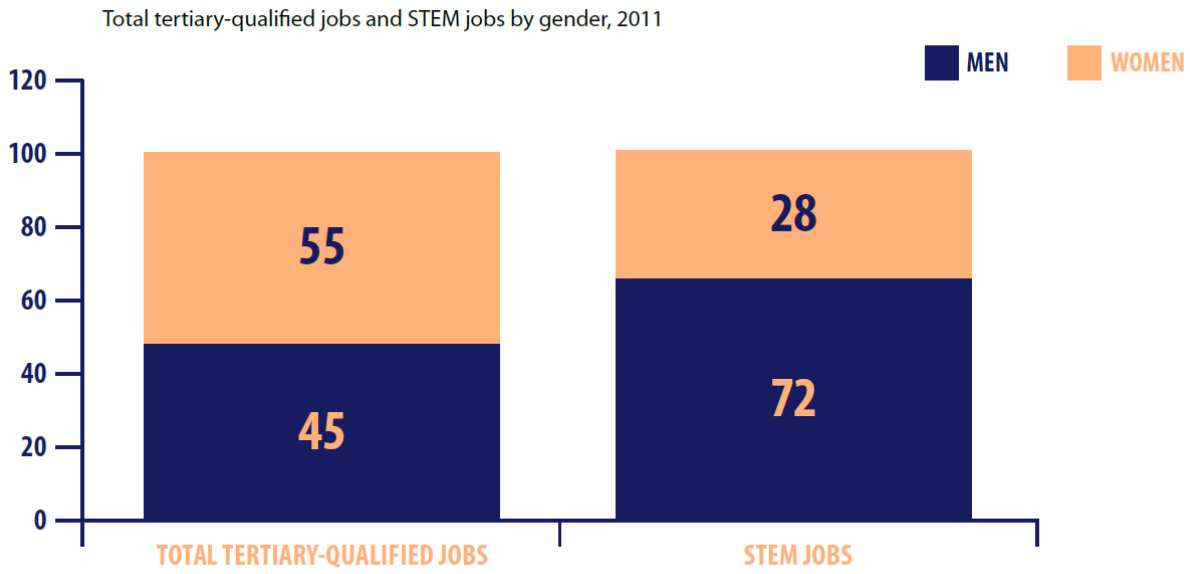
PhD completions in the period 1980–2013 by gender



Source: Peter Johnston, Higher Degrees and Honours Bachelor Degrees in mathematics and statistics, data collection provided to AMSI.

[27] Australian Mathematical Sciences Institute (2014), *'Discipline Profile of the Mathematical Sciences, 2015'*, p.38. AMSI : Melbourne.

… and this articulates directly into the professions within Science, Technology, Engineering and Mathematics (STEM) related fields [28]:



Source:

Healy, J., Mavromaras, K. and Zhu, R. (2013) The STEM Labour Market in Australia. Contributing consultant report to 'STEM: Country Comparisons' project. National Institute of Labour Studies, Flinders University, on behalf of ACOLA. Australian Office for the Chief Scientist: Canberra.

Inequities such as those illustrated above matter firstly because the right to full participation in any aspect of life in a fair and democratic Australia should not be pre-determined by gender, ethnicity or membership of any other social grouping. The evidence tells us, however, that girls' under-representation in advanced level pre-tertiary mathematics and in under- and post-graduate STEM related tertiary education flows directly into under-representation in STEM careers and then also into the professional, economic and personal opportunities these afford.

The relative shortage of women in STEM professions has a marked impact on male / female pay differentials. Following the 2014 release of the annual 'Women in NSW' report by the NSW Department of Communities, Minister for Women Pru Goward pointed to the way in which future economic success and independence of women are underpinned by the choices they make even before leaving school[29]. This is largely because women in jobs that require the study of STEM subjects can earn twice the salary of vocational roles that women have more traditionally pursued. Specifically, Ms Goward stated that:

> *"There is no magic bullet to solve the gender pay divide, but careers reliant on the study of STEM subjects can earn women up to double the salaries of vocations women have traditionally pursued. Girls are 14 percent less likely than boys to study STEM courses at the HSC level. And in undergraduate education, it is similarly bleak at 11 per cent."* [30]

It should be reasonably obvious that persistent gender inequalities such as those that flow from women and girls' participation in the mathematical sciences do not make for a just or socially coherent community. Gender imbalances in mathematics education in Australia are measurable from the beginning of high school and flow down the pipeline into workforce participation and economic disadvantage. [31]

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[28] Professionals Australia (2014), *'Women and STEM in Australia: What is the current state of play, what are the key issues and why does it matter?'* Position paper by Professionals Australia Gender and Diversity Unit. URL: file:///C:/Users/marcus/Documents/AMSI/MANSW/Women%20in%20STEM%20-%20Professionals%20Australia.pdf. Accessed 09/09/15.

[29] NSW Department of Family and Community Services (2014), 'Women in NSW 2014'. Minister's Foreword. NSW DFCS Analysis & Research Division : Sydney.

[30] Riley, J. (2014), *'Women: STEM doubles salary'*. Online article. On www.onlineAus.com, 14 September, 2014. URL: http://www.innovationaus.com/2014/09/Women-STEM-study-doubles-salary. Accessed 09/09/15.

[31] See also diagram on Page 17 of this paper.

From the viewpoint of the 'societal cohesion' rationale, encouraging girls in their mathematical endeavours throughout their schooling, seeking to increase the participation of young women in advanced level mathematics courses and addressing the persistent under-representation of women in STEM related fields must be seen as crucial priorities. Moreover, a state-by-state 'hit-and-miss' approach to this issue by governments and school systems will not be effective. This must be seen as a project of national significance for all parents, teachers, educational authorities and community leaders who consider themselves to be fair-minded Australians.

3) **Individual and Community Well-being.** This last rationale relates to the big questions, "Why is it important for all young people to be mathematically literate?", "How does mathematics empower young people to lead richer, more effective adult lives?" and "What is it we need all mathematics students to be able to do with their mathematical learning?"

In general terms, the importance of mathematics to success in everyday adult life seems obvious and intuitive. Nevertheless, it's nice to have things confirmed by the research. In a study published in *Developmental Psychology* in 2007, a team of international researchers from universities across the US and UK published a study that concluded that early success in Mathematics (measured as success in Year 5 and then in Year 8) is the best predictor of success later in school – *and later in adult life*[32]. In an address to the Silicon Valley Education Foundation's Forum on Early Mathematics, the leader of the study, Dr Greg Duncan, said:

> *"Math coming into school is important because kids who do well in math early on tend to do very well in school. And math is important later on because kids who do well in math in high school end up doing well in the labour market. (Our research shows) the links between school success and achievement in, say, 5th grade or 8thgrade, and the kind of skills that kids bring into school. It's a pattern that seems to be showing up in a number of different data sets from several different countries and different historical periods…"* [33]

Certainly Australian policy makers agree that there is a clear correlation between overall success in mathematics and success in adult life, and that the study of maths enriches and empowers young Australians. The rationale for the Australian Curriculum in Mathematics states:

> *"Learning mathematics creates opportunities for and enriches the lives of all Australians… It develops the numeracy capabilities that all students need in their personal, work and civic life, and provides the fundamentals on which mathematical specialties and professional applications of mathematics are built…"* [34]

To enable *all* students to gain access to these benefits, teachers, parents and the community need to have access to a consistent curriculum that emphasises the set of mathematical capabilities that are important for all students. However, benefits to the private individual flow into our communities and public lives as well. The role of competent and creative mathematicians has been, and will continue to be critical in making our world a better, safer and more beautiful place to live.

Both now and in the future, mathematicians have essential roles in addressing problems and finding solutions in areas such as public health and the control of infectious disease; design and management of public roads, transport and infrastructure; discoveries in molecular biology and breakthroughs in cancer management and viral immunology; environmental, climate and weather event modelling and prediction; advancements in information technology such as voice recognition and robotic intelligence; enhancements

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32 Duncan, G.J. (2007), *'School Readiness and Later Achievement'*. In Developmental Psychology, Vol.43, No.6, pp.1429-1446. American Psychological Association : Washington DC, US.

33 Mongeau, L. (2013), *'Early Math Matters: Top Researcher Discusses His Work'*. Online article, in EdSource.com. URL: http://edsource.org/2013/early-math-matters-top-researcher-discusses-his-work/50061. Accessed 10/09/15.

34 ACARA (2010), *'Australian Curriculum: Mathematics Rationale'*. URL: http://www.australiancurriculum.edu.au/mathematics/rationale. Accessed 10/09/15.

in economic management and regulatory market supervision… The list is, quite literally, endless, as new and emerging fields of technology and science emerge and require the creative and sophisticated application of mathematical logical reasoning, problem solving and predictive modelling.

The young people we are teaching now will be those who will inherit the world with all its challenge and complexity. They will be forced to face new frontiers in science, technology, health, engineering, manufacturing, the arts, environmental and population management. We dare not let them down with a patchwork approach to mathematics curriculum and standards which may, through a lack of a co-ordinated national resolve, fail to deliver on the essential analytical skills, problem solving abilities and logical reasoning capacities that will equip them to successfully meet these challenges.

(E) Conclusion: Towards a nationally consistent mathematics education strategy.

Australia has not been the only Western democracy to have struggled with the issue of the need for nationally consistent standards in mathematics teaching and educational curriculum. In the United States, the implementation of the 'Common Core State Standards for Mathematics' was a response to the issue of state-based inconsistencies in the content, teaching and learning of mathematics in that country. The fact that American students had begun to fall substantially below their international counterparts in broad measures of mathematical achievement was reflected in the preamble to the US 'Common Core' standards document:

"For over a decade, research studies of mathematics education in high-performing countries have pointed to the conclusion that the mathematics curriculum in the United States must become substantially more focussed and coherent… the standards must address the problem of a curriculum that is "a mile wide and an inch deep." [35]

A school curriculum from early years through to the senior years of high school, which focuses clearly and explicitly on mathematical understanding, reasoning and problem solving, is especially critical in a new century marked by constantly changing economic markets, social media and disruptive technologies. According to Dr Jo Boaler of Stanford University:

"The world is changing. We no longer need students to just be fast calculators… in fact, technology now does that for us. We need students who can think and develop mathematical models and reason and problem solve…" [36]

The need for a nationally coherent and robust set of standards for mathematical ability in Australia has not been altogether ignored by policy makers. With the implementation of the Australian Curriculum in Mathematics we now have, for the first time in our history, clear and developmentally sequenced national standards, at least for students from Foundation to Year 10. The rationale for the Australian Mathematics Curriculum states that:

"The curriculum focuses on developing increasingly sophisticated and refined mathematical understanding, fluency, logical reasoning, analytical thought and problem-solving skills. These capabilities enable students to respond to familiar and unfamiliar situations by employing mathematical strategies to make informed decisions and solve problems efficiently." [37]

Tellingly, at the point of implementation of the Australian Mathematics Curriculum for levels Foundation to 10A, Professor Peter Sullivan from Monash University said:

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[35] Common Core State Standards Initiative (2010), *'Common Corer Standards for Mathematics'*, p.3. National Governors Association of the United States : Washington DC.

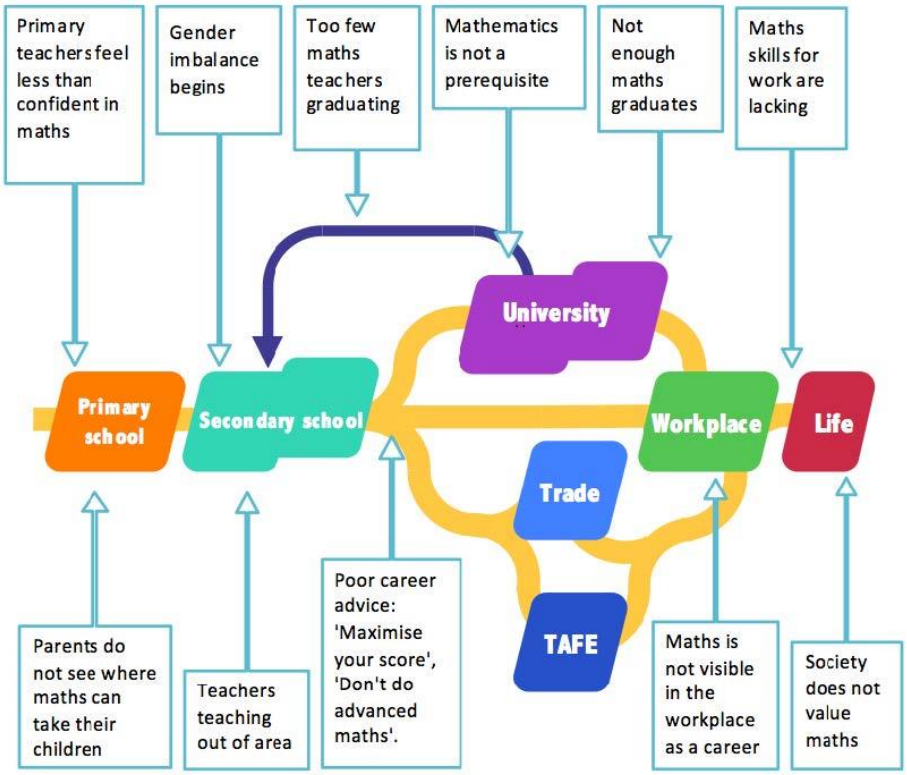
[36] Boaler, J. (2014), 'Why Students in the US need Common Core Math'. YouTube clip - URL: https://www.youtube.com/watch?v=pOOW0hQgVPQ Accessed 07/09/15.

[37] Australian Curriculum, Assessment and Reporting Authority (ACARA) 2012, *'Australian Curriculum Mathematics Overview – Rationale'*. URL: http://www.australiancurriculum.edu.au/mathematics/rationale. Accessed 07/09/15.

> *"An important principle is to make the mathematics clear… there are too many curriculums around the country that are just a whole lot of disconnected points..."*[38]

And yet, as we have seen above, this arbitrary situation still persists with mathematics courses at pre-tertiary (senior secondary) levels. In addition, the application of mathematical pre-requisites to university programs across Australia is chaotic and illogical, often characterised by a 'race to the bottom' as tertiary institutions compete to attract enrolments. In doing so they are frequently forced to overlook whether or not candidates have been adequately mathematically prepared for the requirements of the disciplines they will be entering. In many cases, tertiary institutions are waiving formal mathematics prerequisites altogether.

Each difficulty in the mathematics education pipeline thus contributes to a problem or difficulty further down the line:



Source: McIntosh, J (2014), 'Mathematics in the Pipeline'. Internal AMSI document, supplied by author.

In the words of Jan Thomas, "a national curriculum – even a sensible one – is not a panacea."[39] When the UK introduced their national curriculum and testing in 1988 this had little effect on mathematics achievement and participation until almost 20 years later. Their experience was that it also took national measures to improve the supply of maths teachers, the qualifications, mathematical confidence and competence of teachers and the promotion of mathematics to students and the wider community to "turn mathematics around" in that country[40]. Even a cursory examination of the issues highlighted in the above 'pipeline' diagram show us that the challenges facing educators in the mathematical sciences are numerous and complex, and will need the application of more than one solution.

Nevertheless, the importance of consistent education and training at all levels for our current and future generations of mathematicians is paramount. As the 2006 national review by the AAS concluded:

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38 Ibid (*Video insert: Interview with Prof. Peter Sullivan, Monash University*).

39 Thomas, J (2011), *'Maths Matters: Mathematics Education in Australia, 1980-2011'*, p.136. In the Australian Mathematical Society Gazette, Vol. 38, No.3. AMS Inc : Canberra.

40 Ibid.

> *"Without its own supply of properly trained mathematical scientists and statisticians, Australia's existing industries will become less competitive, and the ability to participate at the cutting edge of scientific research and commercial innovation, or even to be aware of developments, will be compromised."* [41]

A national curriculum in Mathematics from Foundation to Year 10, with core mathematical proficiencies at its heart, is a good start. However, our state and federal educational authorities and policy makers – and we as maths educators - must keep the momentum going.

Extending national consistency and mathematical rigour to all Australian pre-tertiary level courses; increasing overall participation in advanced levels of senior school mathematics programs; addressing the persistent gender imbalances inherent in mathematics education from Foundation through to tertiary studies and beyond into STEM-related professions; and helping to change overall community and societal perceptions of the mathematical sciences, are all components of this critical mission.

Determined support for these priorities is essential from governments at all levels, from business leaders, education authorities, parent groups and from teachers at the 'chalkface'. It is important because, for a range of economic, societal, community and individual imperatives, mathematics matters. Regardless of your chosen beverage or your state of origin, we can all drink to that.

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[41] Australian Academy of Science (2006), *'Mathematics and Statistics: Critical Skills for Australia's Future. The National Strategic Review of Mathematical Sciences Research in Australia'*, p.10. AAS/University of Melbourne : Melbourne.

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