Teaching university physics to students from different school systems: Australia’s state-based education

P R Fraser\textsuperscript{1,2}, L A Sidhu\textsuperscript{2}, Z Jovanoski\textsuperscript{2}, W D Hutchison\textsuperscript{2}, T P Tran\textsuperscript{1}, and J Arnold\textsuperscript{3}

\textsuperscript{1} Learning and Teaching Group, The University of New South Wales, Canberra, ACT 2600, Australia
\textsuperscript{2} School of Science, The University of New South Wales, Canberra, ACT 2600, Australia
\textsuperscript{3} School of Engineering and Information Technology, The University of New South Wales, Canberra, ACT 2600, Australia

E-mail: paul.fraser@adfa.edu.au, l.sidhu@adfa.edu.au, z.jovanoski@adfa.edu.au, w.hutchison@adfa.edu.au, patrick.tran@adfa.edu.au, j.arnold@adfa.edu.au

Abstract. In Australia, the provision of education is a state or territory responsibility. As different states have different curricula and assessment methods, the competencies of students commencing university studies may vary more than secondary school marks may suggest.

We compare secondary school results with outcomes of first-year undergraduate physics studies, as undertaken at the Australian Defence Force Academy. This institution is quite unique, as it draws a student cohort from each jurisdiction.

In Australia, secondary education is administered at a state level. There has been no national curriculum, and each jurisdiction has its own methods of assessment. As a result, variations exist in students’ physics knowledge and mathematical skills based on their state. High school graduates, however, are given a ranking (0.00 to 99.95) known as the Australian Tertiary Admission Rank (ATAR), which purports to compare them to their cohort across the whole nation.

As the name suggests, the ATAR is primarily used by universities when offering places in their degree programs, with students being entitled to apply for institutions in any state or territory. Despite this, the majority of students attend universities in their home state, and within home states the university systems may accommodate for any known shortcomings of their local school system. The University of New South Wales campus in the ACT is an exception, as it delivers the tertiary education component of officer training at the Australian Defence Force Academy (ADFA), which does draw a student body from all states. Thus, ADFA is a useful laboratory for comparing state education systems and the efficacy of the ATAR (and physics comprehension more generally [1, 2]). Variation in the home-state differences in students’ comprehension impacts upon delivery of undergraduate material at this institution.

Preliminary work to date compares ATAR scores with outcomes of 1\textsuperscript{st} semester, 1\textsuperscript{st} year physics and mathematics subjects [3]. Figure 1 displays individual students’ ATAR with results for 1\textsuperscript{st} year engineering physics obtained in the semester immediately after their secondary school completion. Data are shown for three most-populous states of origin - New South Wales, Victoria and Queensland - and was collected between 2007 and 2014. To aid in interpreting these data, the sub-sets for each pair of states are compared in Figure 2.
Figure 1. ADFA students’ secondary school results (Australian Tertiary Entrance Rank) compared with 1\textsuperscript{st} semester, 1\textsuperscript{st} year engineering physics subject marks. Data taken from 2007 to 2014.

The linear regression lines shown in Figure 2 are:

- Victoria
  Eng. Phys. = 0.8831 ATAR – 12.515 ; \( R^2 = 0.2014 \)
- New South Wales
  Eng. Phys. = 1.1764 ATAR – 40.469 ; \( R^2 = 0.2873 \)
- Queensland
  Eng. Phys. = 1.5319 ATAR – 80.723 ; \( R^2 = 0.3023 \)

The line for Victoria excludes the two outliers with raw ATARs less than 65.

A one-way analysis of variance (ANOVA) is a method of determining whether if the mean value of some observable varies between populations by a statistically significant amount. (See, for example, Ref. [4].) Such an analysis was undertaken with post-hoc tests to determine whether the mean 1\textsuperscript{st} year engineering physics results across the seven Australian states and territories were significantly different, and if so, which pairs of means differed. This indicated that the hypothesis of equality of mean results across all states and territories should be rejected (with the probability of observing data at least as extreme as this for the case when all states have an equal mean being \( p = 1 \times 10^{-8} \)). Comparisons of the mean university results of each pair of jurisdictions indicate that they are significantly different (at the 1\% significance level) for
Figure 2. Comparison of results for each pair of states shown in Fig. 1. Regression lines given in text.
Queensland and each other state or territory. When Queensland is excluded, none of the other differences between the states and territories are statistically significant.

While the sample set being drawn exclusively from individuals pursuing career paths in the military represents a sampling bias, the cohort is still useful in comparing a snapshot of the different school systems in a given year, and will allow changes to be tracked over a longer period. We are discussing means of overcoming this, possibly using civilian student data.

Future work will compare ATAR results with skills tests administered at commencement of university studies to measure physics comprehension. A similar study was recently undertaken on three years of data from mathematics skills testing [5]. In this way, the delay between secondary education and subsequent testing will be reduced. (This is even more desirable for the student cohort at ADFA than it would be for students at a civilian university, as changes in study habits and attitudes in a military environment during the first semester of university may be dramatic.) Other factors will be considered that may afford interesting insights, such as year, demographics information (gender) and enrolment details (career paths or degrees in particular). A longer comparison timeframe involving students’ performance in other STEM subjects in later years can help validate the observed patterns.

Variations in the senior secondary curricula of these states during the period 2007 to 2014 were relatively minor. An understanding may be obtained from archived reports and exams, where available [6, 7].

While a consistent national curriculum has not historically been in place, in 2014 one began to be phased in for all school years except the two most-senior years [8]. It is currently beginning to be implemented at these senior years across all states [9]. Future study hopes to track its efficacy in standardising education outcomes as it is introduced in each state. With this information, we plan to work on a systemic approach to designing and implementing an effective university transition program to enhance the capacity of freshman students to succeed in their university studies.

References
[1] Wilson K and Low D 2015 *Am. J. Phys.* 83 802
[2] Low D and Wilson K 2017 *Teaching Physics* 63 17
[3] Arnold J F and Sidhu L A 2015 (Preprint arXiv 1506.07400)
[4] Utts J M and Heckard R F 2015 *Mind on Statistics* 5th ed (Cengage) ISBN 9781285463186
[5] Fox S 2019 *Assessing mathematical preparedness of first-year science and engineering students* Master’s thesis UNSW Canberra http://handle.unsw.edu.au/1959.4/62988
[6] VCAA Examination specifications, past examinations and examination reports https://www.vCAA.vic.edu.au/assessment/vce-assessment/past-examinations/Pages/index.aspx accessed: 2019-10-10
[7] NESA HSC exam papers https://educationstandards.nsw.edu.au/vps/portal/nessa/11-12/resources/hsc-exam-papers accessed: 2019-10-10
[8] ACARA 2014 State and Territory Implementation of the Foundation to Year 10 Australian Curriculum docs.acara.edu.au/resources/State_and_Territory_F-10_Australian_Curriculum_Implementation_Timelines_July_2014_v2.pdf Accessed: 2019-10-10
[9] Australian curriculum https://www.australiancurriculum.edu.au/ accessed: 2020-05-07