An Alternative Pathway for Tertiary Science Education: Managing Student Access, Diversity and Inclusion in Tertiary Level Science

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Abstract

With the global goal of increasing University accessibility and inclusion to a wider demographic of students, managing student diversity in the higher education sector calls for modified approaches to tertiary science education. Student access programs have had various levels of success, with those focused on providing a direct transitory path from secondary to higher education being the most effective. Since adopting a modified admissions policy to the University of Canberra in 2010, we found that students who entered our science-related degrees with an university entry rank or ATAR/UAI of less than 70 or with no ATAR performed poorly compared to students with a higher ATAR/UAI. We have established a new access and preparation program, the Diploma of Science, aimed to cater our diverse student cohort more effectively. The important features of this pathway identified to date include: small classroom teaching with trained teaching staff; trained teaching staff with secondary and higher education teaching experience; and the creation of an inclusive network of support. The one-year Diploma of Science program is designed to articulate directly into our 1st year bachelor science courses providing a 1 + 2.5 model, encompassing foundational knowledge to better prepare students for successful university studies in the sciences and a transformative educational experience.

The student access agenda of higher education

The international context

Globally, the higher education sector has been in a state of transition for some time, a transformation focusing on the creation of an egalitarian tertiary system enabling access and participation from a diverse range of students, many who would previously have not had this opportunity. This transformation has occurred in response to the international recognition that education and the attainment of skills is paramount in achieving and maintaining competitiveness in a globalised world.

In Europe, the Bologna process put in motion a series of reforms, including the establishment of a European Qualifications Framework (2008), to make European higher education more relevant, attractive and accessible to students. In response to the global financial crisis, the European Union's growth strategy for the coming decade, Europe 2020, prioritises smart and inclusive growth targeting better educational attainment, including the goal of attaining at least 40% of 30-34–year-olds completing third level education (or equivalent). Of particular interest is that the priority areas for European co-operation in education have identified that

promotion of equity, social cohesion and active citizenship as central to effective education (European Commission Council, 2012): "Equity and diversity. Reinforce mutual learning on effective ways to raise educational achievement in an increasingly diverse society, in particular by implementing inclusive educational approaches which allow learners from a wide range of backgrounds and educational needs…." (p. 18, European Commission Council, 2012).

Focusing on developing economies, the World Bank prioritises the provision of equity at the forefront of international tertiary education, ensuring students are afforded access to tertiary education with the aim of reducing the divide between their local and global economies. "In today's lifelong learning framework, tertiary education provides not only the high-level skills necessary for every labour market…..develops the capacity and analytical skills to drive local economies, support civil society, lead effective governments and make important decisions which affect entire societies" (Foreword, The World Bank Group, 2002). These programs also specifically focus on enabling access to education for women and underrepresented social groups, providing education opportunities in East Asia, Eastern Europe and Africa.

The Australian context

In the Australian context, the targets set by the 2008 Review of Higher Education (Bradley, 2008) set clear targets for participation, with the goal of enabling attainment of a bachelor-level qualification for 40% of 25- to 34-year-olds, with 20% of undergraduate enrolments in higher education to come from low socio-economic backgrounds. However, in the absence of any clear modifications within the higher education sector in catering for the expansion of diverse student cohorts, there are clear signs that the quality of the educational experience is declining (Bradley, 2008). Deputy Vice-Chancellor of Victoria University, Professor Anne Jones, raised an issue which is often not overtly recognized although easily apparent to most lecturers of large first year subjects; that "attrition rates are likely to rise because universities aren't set up to teach less-prepared students" (Trounsen, 2011). In the same article in *The Australian* newspaper, Professor Peter Rathjen, Vice-Chancellor of the University of Tasmania, suggested that "40% of students are not necessarily going to benefit from an education that was [originally designed] for a very small number of people". Both Jones and Rathjen go on to point out that many of these students require a more hands-on teaching approach that universities find difficult to resource and provide.

With the advent of the My-University website, the Australian higher education sector looks set to face a much higher level of scrutiny than has ever been experienced. The MyUniversity website contains a broad range of information about Australian universities and other higher education providers and in doing so, also facilitates a forum for comparison between these providers. "Education is no longer a business where the provider determines the model. The students are demanding a say too. …The holistic model (enabling high student support) will, no doubt, return". (Stuart, 2012). The importance of evaluating student satisfaction and success in the context of the whole educational experience, and the role of access, participation and inclusion in this experience is critical to ensuring the individual, social and economic value of higher education.

Student access and participation programs for higher education

A response to the changing global demography of students has been the provision of access, foundation or "second chance programs" for those prospective students who have not previously been able to access higher education. Higher education access and participation

program models can be categorised into: 1) Secondary school level intervention; including national curricula; summer programs; and the establishment of specialist schools; and 2) Post secondary school interventions, including; support and mentoring within the mainstream program; zero-level pre-degree courses (1+3 model) requiring no level of prerequisite knowledge; reorganised degree structure (2+2 model) enabling slower progress through a degree; and the complete restructuring of the higher education program (Rollnick, 2010).

Access and participation programs focusing on secondary school intervention may be limited to the extent they can enable a global higher education preparation pathway as they entail an enormous undertaking requiring systemic change (Rollnick, 2010). On a global scale, the International Baccalaureate (IB) aims to provide university preparation and success to high achieving secondary students in IB registered schools through an internationalised diploma program (International Baccalaureate Organisation). In the Australian context, additional secondary school partnerships with the higher education sector do exist, facilitating high achieving students to engage with and prepare for the sector. However, as the majority of global and Australian higher education participation programs are focused on students who are already achieving high grades in secondary school and are often destined for high ATAR scores, many of the students targeted by the greater access and participation programs outlined in the 2008 Review of Higher Education (Bradley, 2008) arrive at university insufficiently prepared.

As highlighted in the Participation and Equity review, students from low socio-economic status (SES) groups, including many indigenous Australians, are likely to have lower perceptions of the attainability of a university place, have less confidence in the personal and career relevance of higher education and be more likely to feel socially excluded from the university culture (Centre for Study of Higher Education, 2008). The design and implementation of the Australian Curriculum aims, in part, to address a unified approach to K-12 learning, however, whether this program has any impact on cohorts requiring more specialised assistance to enable engagement and success will need to be determined.

Student access and participation for science in higher education

What is becoming increasingly apparent is that the abolition of pre-requisites for science in the later years of secondary schooling correlate closely with a decline in engagement with and student preparedness for science in higher education programs (Ainley, Kos, & Nicholas, 2008; Rollnick, 2010). Research in the scholarship of teaching and learning has highlighted that it is difficult to make up for lost opportunities in the sciences, mostly due to the rigorous prerequisites in mathematics and to some extent in science (Rollnick, 2010). Importantly, if students are tracked out of mathematics at an early stage, as if often the case where secondary school career or tertiary study advice steers a student to “easier” options, it is difficult to regain this ground in the normal context of a higher education science program (Goodrum, Hackling, & Rennie, 2000; Ainley et al., 2008). A study at the Faculty of Health Sciences, La Trobe University Australia found that performance in many secondary school science subjects was highly predictive of performance in physiology, combined systematic physiology and anatomy and biomechanics units, while not predictive in new subject areas such as anatomy (Green, Brown, & Ward, 2009).

To provide further context to the decline in science engagement and participation, poor school results in secondary maths and science has led to a shortage of science education graduates and high quality science teachers, creating a vicious cycle of science engagement

and performance (Harris Jensz, & Baldwin, 2005; Rollnick, 2010). The higher education system of South Africa provides a unique case study, where apartheid systematically excluded the majority of the population access to the sciences, and the long-term forecast on the society post-apartheid was identified as having a devastating impact on the country's economy if not addressed (Rollnick, 2010). An Australian study commissioned by the Australian Council of Deans of Science identified that more than 40% of senior physics teachers did not have a university physics major and one in four had not studied in the subject area beyond first-year at university level (Harris et al., 2005).

The most successful student access interventions to date have focused on understanding the background of the students in the provision of a transition pathway between secondary and tertiary schooling (Rollnick, 2010). In addition, programs modified at first year to include essential background content, rather than simply reducing the pace of the program, are increasingly favoured in preparing students for subsequent years (Rutherford, 1997).

Case study of the Faculty of Applied Science at the University of Canberra

Managing student access, diversity and success

In 2010 the University of Canberra modified its admissions policy to include various admission pathways, enabling access to higher education to students with a wider range of Australian Tertiary Admission Ranks (ATARs) than in previous years, across all disciplines. The ATAR replaced the former Universities Admission Index (UAI) across the Australian Capital Territory (ACT) and New South Wales (NSW) in 2009, becoming a tertiary entrance ranking scale across Australia, excluding Queensland, in 2010. The ATAR system is not significantly different to the UAI in any way that affects this study. The ATAR is a ranking system based on a combination of school-based assessment and final examinations (University Admissions Centre, 2011). The ATAR is designed to provide some comparability between students throughout NSW, Victoria and the ACT and is based on the total number of students within any year cohort who completed Year 12.

To set the context of this case study, in 2010 and 2011, the median national ATAR was 69.80 and 69.25 respectively (ATAR 2011, Universities Admissions Centre). In 2008 the ATAR entry to the University of Canberra bachelor courses in the Faculty of Applied Science had been lowered from 75 to 65 to stem the decline in the number of students nation-wide studying science at tertiary level. Several other changes were made to the admission pathways to the bachelor programs. A greater number of students were facilitated to enroll with no ATAR/UAI through direct entry and application to the university, including mature-age and international students often with limited or no science background. In addition, student access pathways were adopted to enable students from low socio-economic and regional areas to gain up to an additional 10 ATAR on their raw ATAR scores to gain entry to the bachelor programs.

Concurrently, no pre-requisites were set for entry into the bachelor degree pathways. The removal of specific science and maths pre-requisites created a context where many of the ATAR entry students also had limited or no science background. As an indication, in 2012 less than 50% of our cohort entering the first year chemistry unit Chemistry 1a with an ATAR had studied chemistry in Year 11 or 12 (unpublished data: Simson, Kelly and Woolnough). The broadening in the admission pathways resulted in a significantly larger and diverse cohort of students enrolled in the first year foundational units across the campus.

University-wide, several short-term non-discipline focused programs were put in place to orientate students with an ATAR/UAI below 70, however, these were focused on basic university orientation rather than academic support. Additionally, in support of the bachelor programs in the Faculty of Applied Science and Faculty of Health, the Science Resource Centre provided an extensive support system incorporating on-demand support through peer mentoring, one-on-one assistance, IT support, study areas, support staff and social common areas. Previous in-house evaluations indicated that although many students engaged with these programs did benefit both academically and socially, there remained an alarming trend in the inability of many students to cope with the first year bachelor program.

Within the Faculty of Applied Science at the University of Canberra the two 1st year science foundation units, Concepts in Biology (CiB) and Chemistry 1a, core units to all the bachelor degrees within the faculty, had around 400 students enrolled at census in 2010 and 2011, a point at which students can withdraw from units of study without financial implications. Typically some 30-50 students would have already withdrawn from these units at this stage and were not included in this preliminary study. It should be noted that the preliminary findings of this case study were reported in the 2011 Australian Conference of Science and Mathematics Education proceedings (Simson, Moore, Woolnough, & Pittard, 2011).

An evaluation of unit incompletions or unit failure in the first year biology unit, Concepts in Biology (CiB) highlighted the proportion of students in different ATAR/UAI categories not able to complete the first year biology unit, a trend increasing with an ATAR below 75 (Figure 1). Of additional concern was the downward trend in success when ATAR grouping were compared for the period 2010 to 2011, with poorer levels of success found across the ATAR range in 2011 (Figure 1). It should be noted that unit incompletion figures did not include students who had pulled out of the unit of study prior to census date, the date at which students can withdraw from a unit without financial penalty. Unit incompletions were therefore directly correlated to a lack of student academic success.

Table 1: 2010 vs 2011 comparison of total student numbers within each ATAR / UAI category for the first year biology unit, Concepts in Biology

Year (total Students)	No ATAR n	<65 ATAR n	65-75 ATAR n	75-85 ATAR n	>85 ATAR n
2010 (393)	136	48	91	89	29
2011 (379)	156	48	67	73	35

Of particular interest is the significant group of students, 35% in 2010 and 41% in 2011, who entered our bachelor program with no ATAR/UAI score, exhibiting the highest incompletion rates of 43% and 48% in 2010 and 2011 respectively (Figure 1). This group included a small number of international students, of whom 43% failed to complete the unit, as well as mature-aged and regional students. The complex demographic of this group is highlighted by the broad spread in final marks exhibited in this group (Figure 2) and is a focus of further study in the first year program.

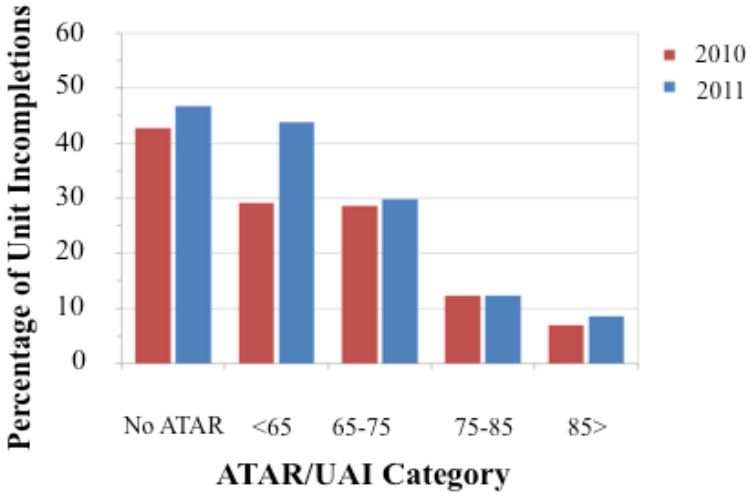

Figure 1: 2010 vs 2011 comparison of the percentage of students within each ATAR / UAI category that did not complete the first year biology unit, Concepts in Biology. Minimum entry requirement to bachelor program of ATAR/UAI 65 in 2010/2011, lowered from 75 in 2008. Direct entry students have no ATAR/UAI score. New access pathways to the Bachelor program credited up to 10 ATAR points for students from low socio-economic and regional areas, enabling students with raw ATAR's below 65 (the <65 group) to gain admission to the bachelor programs (Simson et al., 2011).

The situation where more than 30% of <65 ATAR and 40% of no ATAR/UAI cohorts failed to successfully complete the first year foundation unit in Biology is not acceptable. As previously highlighted through in-house evaluations, up to 50% of students enrolled in these units did not complete any science at senior secondary level, correlating with a national trend in the decline of secondary school students participating in the sciences since 1992 (Goodrum et al., 2000; Ainley et al., 2008). It is important to note that incompletion rates continue to grow in direct correlation with the proportion of students studying biology in the < 65 ATAR or no ATAR cohorts, increasing from 46% to 54% in the period 2010 to 2011. Many of these students would not have considered university study even 5 to 10 years ago, and have now had an unsuccessful, and we presume, unhappy experience of the university sector, which may affect their attitudes to further study for a long time (Centre for Study of Higher Education, 2008).

Although ATAR/UAI is not the only predictor of success it is clear that students with an incoming ATAR/UAI of less than 70 have diminishing chances of passing the unit, particularly considering that final marks represented in Figure 2 only includes those students who attempted and received a mark for all assessment items. Upon first evaluation the spread of final marks appears to be fairly consistent between the no ATAR/UAI, <65 and 65-75 groups, however, these figures need to take into account the percentage of students attempting all assessment items (Table 2). Table 2 highlights that between 2010 and 2011 we see a 15% decline from 70% to 55% of students attempting all assessments in the <65 ATAR/UAI group. A comparison with students in the 75-85 and >85 ATAR/UAI groups illustrates not only a smaller spread in final marks (Figure 2), but a consistently higher rate of assessments being attempted between the 2010 and 2011 study period. In fact an admission ATAR/UAI of 75, the pre-2008 admission ATAR/UAI minimum, is correlated with a >50% final mark for students who attempt all assessment items, and unit completion. Our on-going studies are focused on further elaboration of the correlation of unit completion of the first

year science foundation units with science prerequisite from the secondary sector for low and high ATAR/UAI students, or through work experience or prior study for the no ATAR/UAI cohort.

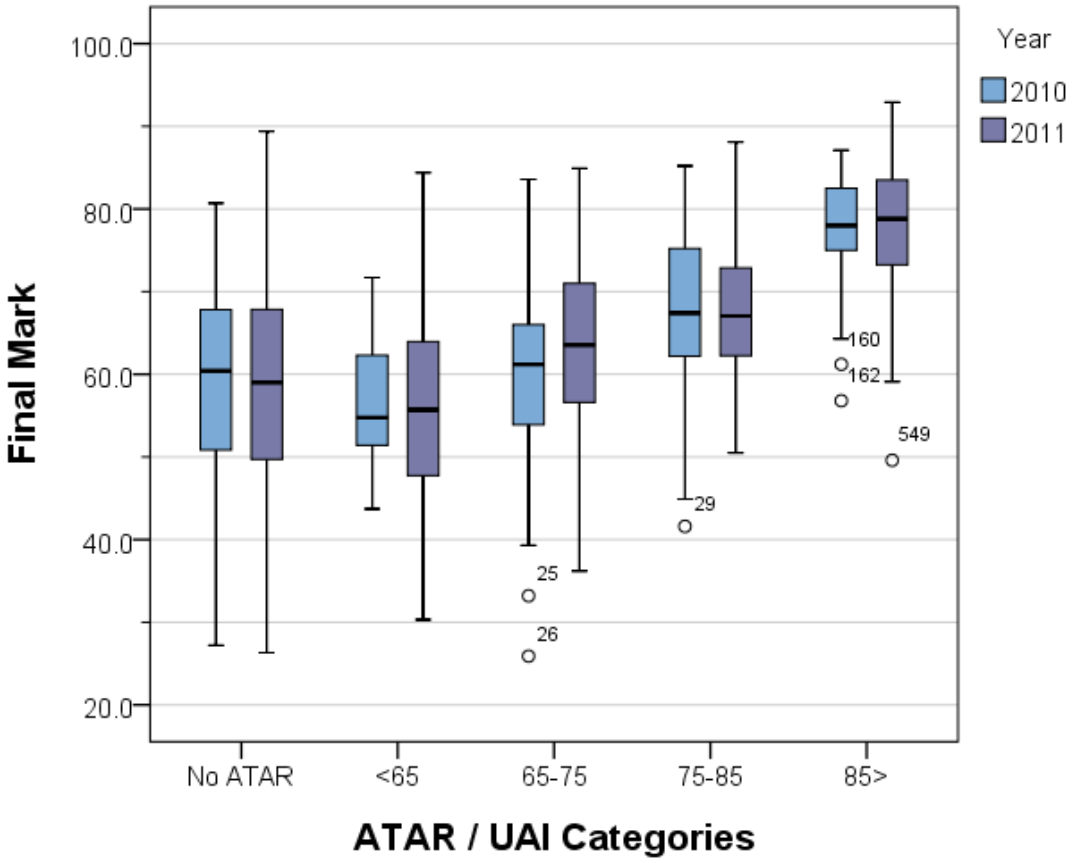

Figure 2: Final mark by ATAR/UAI categories for all students who attempted all assessment items for Concepts in Biology 2010 and 2011 (Simson et al., 2011).

Table 2: The percentage of students who attempted all assessment items in Concepts in Biology 2010 and 2011. (Total student numbers used to calculate percentages taken post-census from Table 1)

Concepts in Biology					
Attempted all assessments (%)					
ATAR/UAI	None	<65	65 - 75	75 - 85	>85
2010	57	70	71	88	93
2011	52	55	70	88	91

A more recent evaluation of the final marks for all students in the first year Chemistry unit, Chemistry 1a, illustrated the strong correlation (R square 0.709) between admission ATAR/UAI and student success or failure in the unit (Figure 3) as measured by a final mark greater than 50%. Upon further analysis, an even stronger correlation (R square 0.838) was found between ATAR/UAI and final marks for regional students (Figure 4). As previously mentioned, many of the students gaining entry to the bachelor courses through regional secondary schools or low socio-economic areas gain up to an additional 10 ATAR on their raw ATAR scores to facilitate university admission.

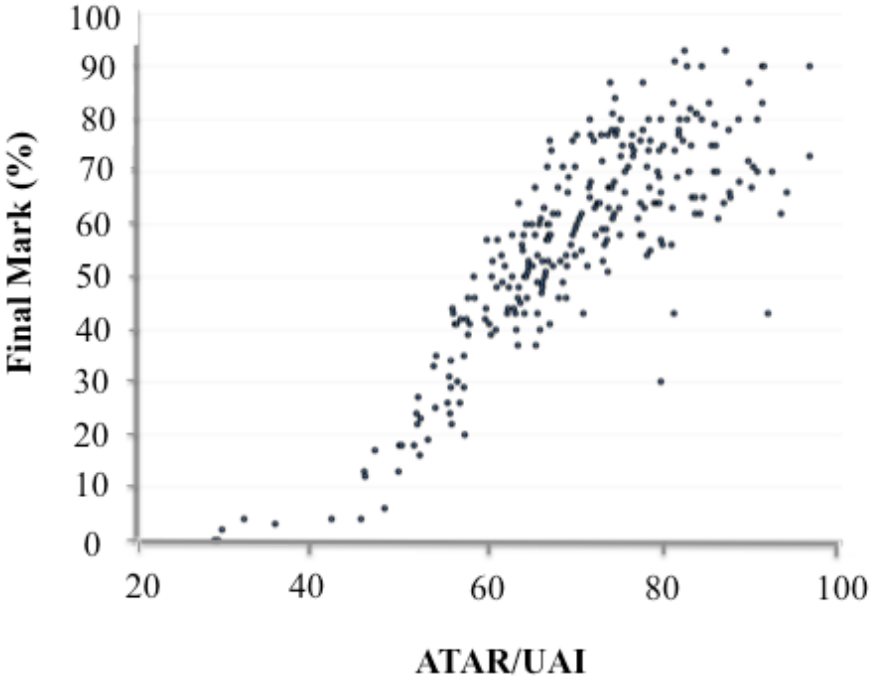

Figure 3: Final mark by ATAR/UAI categories for all students who attempted all assessment items for Chemistry 1a 2012. A correlation of R square .709 was identified between admission ATAR/UAI and final mark (%).

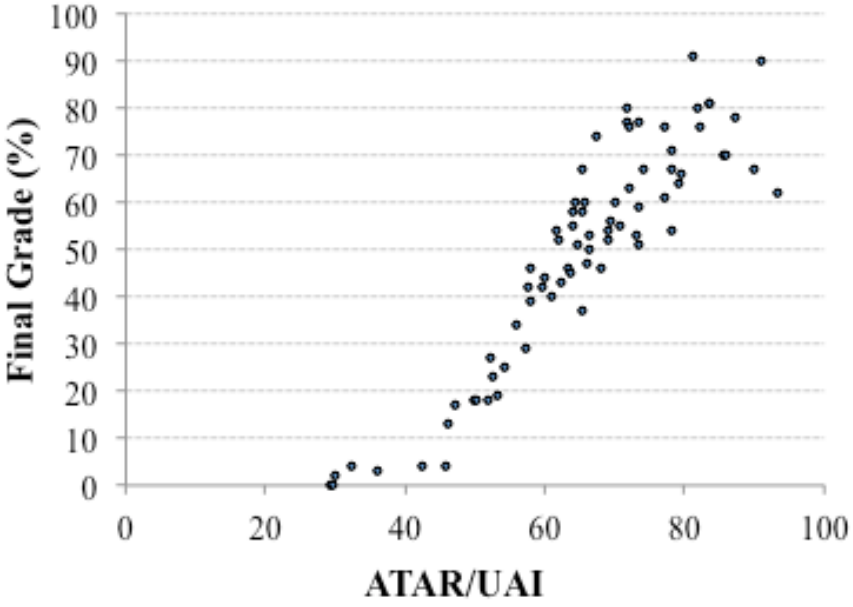

Figure 4: Final mark by ATAR/UAI categories for all students gaining regional admission who attempted all assessment items for Chemistry 1a 2012. A correlation of R square .838 was identified between admission ATAR/UAI and final mark (%).

Further analysis was performed on raw ATAR scores with the removal of the top-up ATAR points allocated to regional and low socio-economic status students. Students with raw ATAR's less than 60 represented 12 % of the 2012 cohort, doubling from 6 % in 2011. Importantly, only 2 of 49 students were able to successfully complete the unit with a grade

just above 50% (Figure 5). As in our evaluations of the Concepts in Biology cohort, further studies are being undertaken to evaluate the correlation between science and mathematics pre-requisites on unit completion and final marks in the first year program.

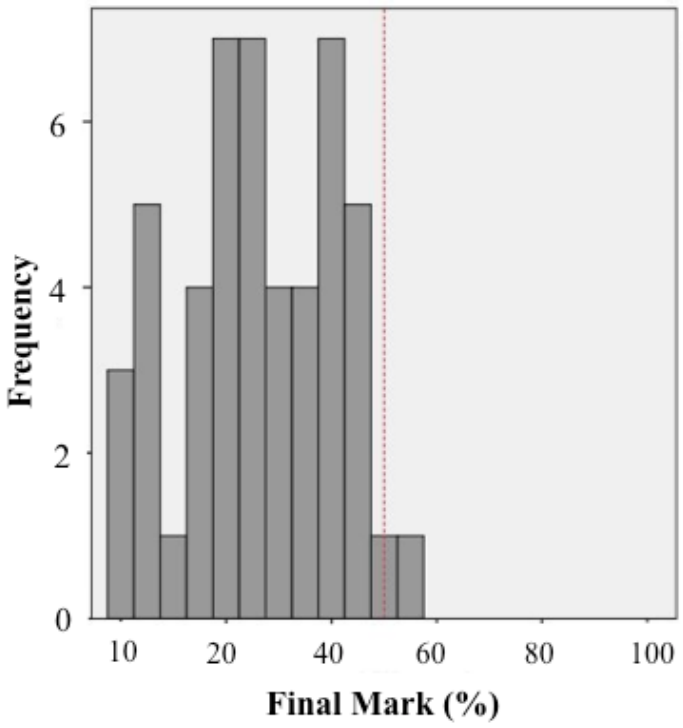

Figure 5: Students with raw ATAR's <60 represented 12% of the cohort and 33% of all Chemistry 1a 2012 fails. Only 2 of 49 students were successful in gaining a final mark (5) greater than 50%.

These preliminary studies within the Faculty of Applied Science of the University of Canberra highlight the impact of a drastic change in university admission policies in producing a cohort of students for whom the old approach to higher education in the sciences is no longer adequate. Extensive support structures during their first semester of study and the traditional entry pathways are no longer sufficient to enable student success. In the context of the access agenda, University level education has now become available for many people who would not have had such access only a few years ago, many of whom are poorly equipped for managing the transition to higher education let alone studies within the science discipline. Many students in this diverse cohort have a negative and unsuccessful experience and new ways of enabling success are required if we are to achieve the aspirations of the 2008 Review of Higher Education (Bradley, 2008) in the provision of access, equity and inclusion within the tertiary sector.

A new model for tertiary science access at the University of Canberra

In response to the attrition crisis in the science discipline, we have designed and implemented a new student access and preparation program: the Diploma of Science. The Diploma of Science is designed to provide students with a solid grounding in basic concepts in science, including biology, chemistry and physical science, as well as providing skill development in arithmetical techniques, English communication and science study skills (Figure 6). 50% of the units included in the course are augmented, high support versions of current first year science foundation units. The 1 + 2.5 model allows the one-year Diploma program to

articulate directly into the bachelor science courses, providing 6 months credit towards the first year of each science degree.. In addition, the foundation knowledge embedded in this pathway is designed to better prepare students for successful university studies in the Sciences. The course aims to maintain intensive treatment of course material, but in a small classroom context, with extra time used for including essential background material and development the necessary skills for students to engage meaningfully with the course material. Importantly, we will continue to evaluate both student and staff feedback through qualitative surveys on the design, implementation and further development of the course, in addition to the analysis of student success via quantitative correlation of student success and retention through the Diploma pathway vs direct entry to the Bachelor courses.

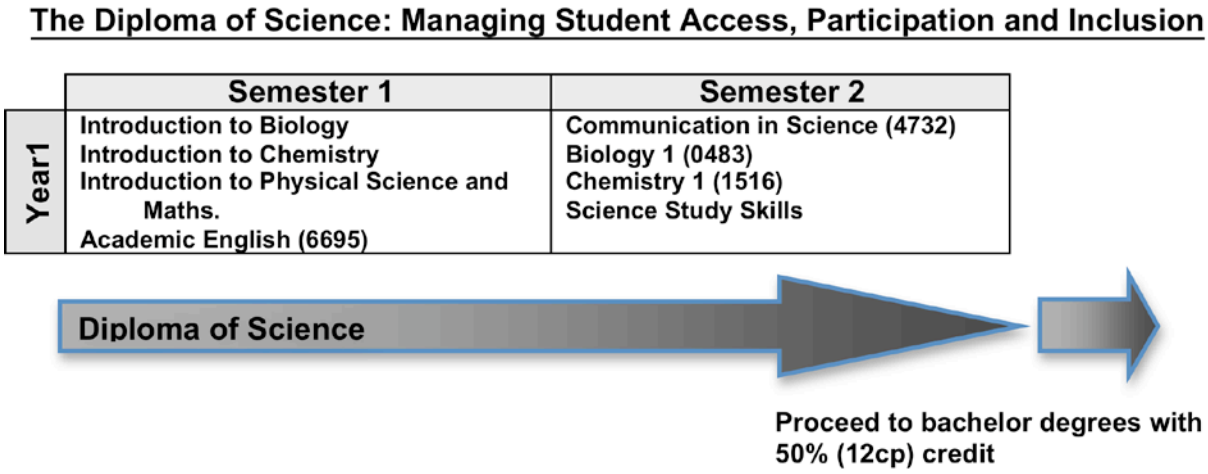

Figure 6: The Diploma of Science model provides an alternative admissions pathway articulating to our current science bachelor degrees. The 1 + 2.5 model provides 6 months credit towards the Bachelor of Science courses.

In 2012 we are piloting the Diploma of Science access program with an initial cohort of 25 students, and first impressions have already highlighted some significant impacts of the new pathway. From staff feedback, the cohort has already formed an inclusive group of highly motivated and participating students, students who may have previously disengaged from the study program. The importance of social inclusion and social networks in facilitating student engagement, participation, success and retention will continue to be analysed and evaluated through ethnographic studies, and will provide an interesting reflection to ways of improving opportunities for engagement and participation in the bachelor program. In parallel to the Diploma of Science pathway, the supportive networks created by the Science Resource Centre peer mentor program will be harnessed in providing strong inclusive support networks with our bachelor pathways, , facilitating learning and workplace skills. Case (2007) highlights the importance of creating social connections in the context of effective engagement, and conversely the negative impact alienation can have on the student learning experience.

One of the most important aspects of the Diploma of Science is in the selection of teaching staff in delivery of the course. All teaching staff are fully trained teachers with both secondary and tertiary teaching experience, the importance of which has been highlighted in previous studies. Rollnick (2010) emphasises that pedagogically designed teaching of students with little or no background in the sciences is critical in achieving learning outcomes, and all too often, teachers at the tertiary level have not received enough training in

education to effectively cope with teaching large classes of students let alone coping with students with little or no background in the sciences. Rollnick also emphasises the importance of growing a culture of scholarship of teaching in the sciences to facilitate effective access and bachelor program support.

Preliminary data from the first teaching period of the diploma can be provided by a direct comparison between the first year chemistry bachelor and diploma cohorts in the chemistry units Chemistry 1a and Introduction to Chemistry which identified a 60% increase in student completion for students studying the diploma unit.

From 2013, the Diploma of Science pathway will be expanded to become the preferred admission pathway into studies in the Sciences at the University of Canberra for several cohorts of students: 1) Domestic onshore students with low ATAR/UAI entry scores; 2) Students who have an ATAR/UAI above 65 but have not completed studies in the Sciences at senior secondary school; and 3) International students. Importantly, the small group sizes and teaching styles will be retained, aiming to retain and harness the benefits of this preparation pathway. The expansion of the Diploma of Science could not come at a better time, with 34% and 44% attrition in the first year foundation biology and chemistry units respectively in 2012 highlighting the need to better accommodate for preparation, access, participation and social inclusion in the Sciences.

Conclusion

The global transformation to increased access to the higher education sector for non-traditional participants highlights the limitations of the higher education sector, in its current form, in catering effectively to a more diverse student cohort. In the sciences, a decline in engagement with tertiary science and student preparedness can be linked to the abolition of science pre-requisites and 'easier' study options at the secondary level, resulting in the vicious cycle of science performance. This case study In the context of new admissions pathways focused on facilitating greater student access at the University of Canberra in alignment with the University strategic plan enabling greater student access, and participation we have created a new model for tertiary science education, the Diploma of Science pathway. The Diploma of Science aims to provide an inclusive access program at a time where we are striving for 'a university education for all', as well as "education as a transformative experience for all people irrespective of their origins, age and circumstances, to be used for the public good" (University of Canberra, Strategic Plan, 2008-2012).

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