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The ALURE of Massified Undergraduate Research

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Undergraduate research experiences have enormous benefits for our students, but the numbers of students who participate are tiny. Over the past two years our team has been working with the Australian Office of Learning and Teaching (OLT) to increase the numbers of Australian undergraduate students engaging in scientific research. We call our communal effort 'The ALURE Project'. ALURE stands for Authentic Large-scale Undergraduate Research Experience. In this article we report on our progress and discuss some of our findings as we work with ALURE implementers across Australia.

Why Bother with Undergraduate Research Experiences?

Providing undergraduate students with meaningful research experiences is not easy, so it is important to ask why we should do it. In the traditional, apprenticeship-style undergraduate research model, a single student works in a professional research laboratory on their own project. This model provides a powerfully authentic research experience, but it can be of variable quality, both in terms of the student's ability (1) and the supervisor's input (2). Even with this variation, however, research shows that undergraduate research experiences are important opportunities for high-impact learning (3). Undergraduate Research Experience (URE) students are very engaged in learning and they experience profound changes in their sense of 'being a scientist'. They also improve their understanding of the research process, increase their awareness of science careers, and develop their professionalism. In a key benefit for the entire science community, these students are also more likely to complete their degree program and go on to higher degree study (3-8). All of these URE outcomes are positive. The question is, are enough of our science students able to participate in the experience?

How Many of Our Undergraduate Science Students Participate in UREs?

A 2009 study led by ALTC National Teaching Fellow Angela Brew (9) identified 128 URE programs in Australia, serving a total of 3,500 students (10). A large proportion (66%) of these programs were science-based (offered in Science, Engineering, Health, and the Built Environment) (10); a quick calculation shows around 2,300 science-oriented students were served in 2009. These numbers sound healthy until we consider how many students we actually have in the educational system. In 2009, there were

nearly 240,000 Australian university students enrolled in programs classed as 'Natural and Physical Sciences', 'Engineering' and 'Health' (11). Apparently then, in 2009, the Australian science URE programs served less than 1% of students in the Science pool!

National surveys of Australian tertiary students in 2008 and 2009 corroborate this calculation (12,13) but equivalent surveys in the USA provide us with a very different picture. There, 5% of all first-year and 19-20% of all later-year students reported taking part in a URE (14,15), and efforts are ongoing to increase these numbers (16).

Why do we in Australia only achieve a 1% uptake? How can we work with students and scientists to massify the Australian URE? In 2012 the ALURE team started asking these questions through our OLT-funded Leadership for Excellence in Learning and Teaching Grant.

Lessons from America

The US system provides many lessons on how to make large-scale undergraduate research a reality in Australia. There, students are commonly engaged in small-group UREs in undergraduate laboratories. These projects often provide the life-blood to academic scientists' research programs at four-year colleges (17). The US Science funding system recognises the important role of undergraduate research and it supports the students and academics who are involved. URE programs in the US are well-funded by the National Institutes of Health, the Howard Hughes Medical Foundation and the National Science Foundation. An example is showcased at <http://hhmi.mcdb.ucsb.edu/lure>.

The Australian URE Model

The US model is different to the one we find in Australia. Here, most URE programs use a one-on-one mentoring model (18) and they are characterised by limitations in student numbers and competitive entry criteria (10). Most are university-driven programs that arose in an attempt to increase the size and quality of Honours and PhD cohorts (10). Consequently they are targeted at gifted, highly-motivated students; this is reflected in selection criteria that almost all start with high academic merit, then most frequently require students to have an interest in pursuing a research path (including Honours or PhD). In many cases, students are more likely to be admitted to the URE program if they have prior research experience. Most Australian

UREs run in holiday breaks, when students may need to work or care for their family.

This competitive, exclusive model looks uninviting for many of our undergraduates. Consider the low socioeconomic status student who needs to work outside regular university hours, the mature-age student with children, and the exploratory, non-strategic student with less than stellar grades – are they less worthy URE participants than the students who are chosen in the current URE system? We would argue that they are not.

The Challenge to Massify UREs

Undergraduate research does not have to be a boutique endeavour that targets the most gifted or persistent students. It can be an experience that is open to the wider student body. In our recent work (19-21) we have shown that large-scale UREs can work well with sizeable groups of students who are not all high-achievers. We have used this experience as the basis for the ALURE Project.

Defining an Authentic Large-scale Undergraduate Research Experience (ALURE)

Perhaps most crucially, an ALURE must happen during the regular laboratory time offered to students enrolled in undergraduate courses. Beyond this requirement, an ALURE has several components:

Authentic: ‘Authenticity’ is a multi-faceted term. Jonassen (22) describes authentic learning as personally-interesting, with learning activities and assessment tasks that require students to think and act as they would in the real world. Presenting research results as a short paper, a poster or a talk would count as ‘authentic’. Authentic activities have also been defined as collaborative, complex and incompletely structured (23,24). This means the students who complete them must consider multiple perspectives, paths and solutions while they engage in critical thinking and evidence-based decision-making.

Our concept of authenticity for undergraduate researchers envelops these definitions and goes further to encompass the

idea of new discoveries. We suggest that ALURE students should be working on a problem that is unanswered, and that they should communicate their results to someone with a genuine interest in the information. These audiences are diverse and may include the researcher whose work underpins the ALURE, the next cohort of students who will continue the work, or government, industry or public groups who see the research as important.

Authenticity is a key component of ALURE, and it sets ALURE apart from traditional undergraduate laboratory experiences where students are completing stock experiments with known answers. Authenticity also makes ALURE more than an inquiry-task, which typically allows students to add to their own knowledge through questioning and experimental design, rather than adding new knowledge to the field.

Large-scale: This is a flexible term, but generally we consider any group that cannot fit into an academic research lab to be large-scale. The authors routinely run ALUREs for up to 300 students in our undergraduate class sessions. This is a clear difference in scope from a pair or trio of students working in a professional academic research laboratory. The size of the group does place limits on the activities that can be done, and the freedom that students have to pursue their own research ideas. Nevertheless, students are working on a real project with an unknown answer, so their activity is still classified as research.

Undergraduate research experience: A research student should be working on something that has an unknown answer, and we have already discussed this. Of course there are many other parts of a research experience that we can consider, and there is considerable literature around the definition of the term ‘URE’. Spronken-Smith *et al.* (25) suggest that there “is a cyclical nature to the activity involving identification of the problem, gathering information, analysing data and synthesising findings, communicating results, evaluating outcomes and generating new questions for future research.” These activities are all important, and in an ideal URE they

Fig. 1. A series of continua used to illustrate the diversity of characteristics across URE programs in the USA (adapted from Beckman and Hensel, 2009). The terms on the continua can be interpreted as end-points for the limits of a ‘research experience’ in the lived curriculum (as defined by the academics who conduct these UREs). Prefixes for each continuum are shown on the left.

The Learning Objective of the project is	Student and process centred	↔	Outcome and product centred
Selection of the research topic is	Student initiated	↔	Faculty initiated
Students who can access the URE are	All students	↔	Honours students
How is the URE integrated into the program of study?	Part of the curriculum	↔	Co-curricular activity
What is the mode of student work?	Collaborative	↔	Individual
The results are	Original to the student	↔	Original to the discipline
The skills learned are	Multi- or inter-disciplinary	↔	Discipline-based
The results are communicated to	Campus and/or community audience	↔	Professional audience

would all be included and taught.

The large scale of an ALURE means, however, that sometimes we need to make compromises about the ratio of independent research to skill-building, and the amount of independence that students have to design the research project and choose the methods. These compromises are legitimised when we consider the results of a nationwide American survey of URE implementers (26). This work found that there is considerable scope in the design and delivery of UREs (Fig. 1) and the authors concluded their paper by stating "there is no one correct definition. One size does not fit all. An institution will best access the many benefits of undergraduate research by carefully formulating a definition or definitions that fit." The results give us confidence that the ALURE model is suitable for widespread implementation in Australia.

The ALURE Project

The ALURE project aims to gather and share information with academics and administrators about how we can give more students a URE experience.

Perhaps the simplest way to develop wide implementation of ALUREs would be to change the extant science funding culture in Australia to support teaching experiences. In the most recent Federal Budget, the Government sent a clear signal about their feelings towards subsidised education. We can assume that more financial support for undergraduate research is not on the cards in the near future. What, then, are the practical alternatives?

We know from our own experience that ALUREs require significant effort and resources, especially at the time of start-up. We also know that once an ALURE is running it can be remarkably cost-effective to sustain. The major barrier to ALURE uptake appears to be at the development stage, so in 2012, we began work on two mechanisms to help ALUREs become widespread in Australia. We are building a Community of Practice for ALURE practitioners as well as collecting, collating and discussing information that can be used to give high-level university administrators a compelling and well-evidenced case for supporting ALUREs in their institutions.

A Community of ALURE Practitioners

A recent Australia-wide audit showed that, at best, URE programs are supported throughout an individual university, but at worst they are championed by lone academics (10,27,28). A major goal of our project has been to work with, support and connect these individual and institutional champions to take UREs beyond the boutique and into the larger student population. We began the project by documenting the extant practice of four people who had successfully implemented and sustained ALUREs at their universities, without the help of our team. We have also worked with and mentored twelve implementers at four universities to set up and/or evaluate ten ALUREs. As our new implementers devise and start up their ALUREs, they develop the experience and leadership capacity that is driving local change at their own institutions.

It has been fascinating for us to see the factors that help new implementers develop ALUREs. In all four of our new

university implementation sites (University of Queensland, Deakin University, University of NSW and Curtin University), a central change agent has taken up the idea of ALURE and provided the leadership required to support their colleagues. The ALURE Project team has helped the new implementers with visits, ethics applications, protocols, Skype calls, evaluation tools, data analysis and rapid email clarification of queries. This instantaneous, personal help is key as it allows new implementers to quickly sort out small problems before they become larger ones. Interestingly, we failed in our attempts to set up an online Community of Practice. The help available through the online network was not fast nor personalised enough to support the needs of our new implementers, but it may be successful in the future, when the pool of experienced mentors is larger. The personal approach though, has been very successful. In three of the implementation locations, the ALURE program has spread out from the initial course to further courses. A fourth implementation is in its first iteration, but we expect the dynamic team involved will successfully propagate ALURE beyond their immediate single course.

Making the Case for Institutional Support of ALURE

Universities almost always desire evidence of improved student learning (or engagement) to support their ongoing commitments to teaching innovations. ALUREs do need some initial start-up capital and time, so this desire for evidence becomes an imperative. Consequently, we have been collecting data about the student and the implementer experiences of ALURE. Our methods are varied (Table 1). We are using the resultant data to build a detailed picture of the ALURE students' self-reported gains in skills and professionalism, while comparing these to non-ALURE students. We are also examining students' willingness to continue in science as a result of their ALURE.

Our students report significant gains in laboratory skills, resilience, time-management and professionalism, just like the students who compete an apprenticeship-style URE. Perhaps most importantly for academic scientists, many ALURE participants say they used the experience to decide whether or not they enjoyed and wanted to continue in research. Consequently, we can say that ALURE reduces the numbers of unprepared and/or uncommitted students who begin a URE in the academic laboratories. One student, when asked if she had changed her opinion of what being a scientist is like said this:

"I think yeah it did for me. Like, at first I thought research was, 'oh you know you're stuck just doing the same thing' - like every day and stuff. But doing ALURE... it was really interesting. I felt excited getting our results and thinking 'oh we did all this work to get this result'. I loved that feeling. ALURE just made me think, like, research isn't just being stuck in the lab pipetting all day. If you do the stuff, you'll get results."

We have also asked our implementation teams about their experiences. The results are overwhelmingly positive, with reports of good staff-student interactions, increased enjoyment of teaching and strong financial and organisational support from university administration.

"I think [I got] a lot of enjoyment because it worked out quite well. In terms of the research there were some interesting results,

Table 1. Methods used to gather and analyse data for the ALURE project.

Method	Study Subjects	Purpose
Pre and post skills and interest survey	Students	Students self-report the changes in their levels of skill and interest.
Post modified URSSA survey (29)	Students	Students self-report the changes in various attitudes and behaviours that relate to professionalism and affect.
Reflections	Students	Students provide short reflections at the end of semester using a Roses, Buds and Thorns approach.
Post focus groups	Students	Discussion focused on the student experience, including 'helps', 'hindrances' and suggestions for improvement, the students' sense of participating in and learning about 'real' research, the support they received and their future plans.
Discussion transcripts	Implementers	Questions and concerns raised by implementers are recorded and examined for content. Help given to implementers is recorded. These items establish needs experienced by implementers.
Post interviews	Implementers	Discussion focused on the implementer experience, particularly factors raised in the literature (10) associated with challenging or supporting the introduction of a new teaching innovation.

in terms of the student interaction that was great being able to guide students in the right way and hopefully make a change in the school. That was a great experience."

So rosy is the picture that we are now actively looking for mechanisms to access people who want to include an ALURE, but cannot due to restrictions imposed by time, money or institutional structures. We understand why ALURE implementation does work, and are now trying to understand why and when it doesn't.

Conclusion

The Boyer Commission Report (30) set in motion an international educational movement placing a new emphasis on the role of undergraduate research within higher education. Today, the education literature continues to report the variety of ways students engage with research (26,27,31,32) and the potential benefits they gain (4,7,8,33). The diversity of models for these activities, both within and alongside the curriculum, may inspire other institutions to examine the diversity of the experiences that they offer. Our project has gone part of the way to making wide adoption of ALURE a reality, and we hope to continue working on this goal into the future.

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