

## INDUSTRY COLLABORATION THROUGH WORK-INTEGRATED LEARNING IN A CAPSTONE UNIT

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*During the last decade, many universities across the world have increased industry-focused curriculum development to prepare graduates for the workforce. This shift has usually involved collaboration with industry representatives as partners in curriculum development, and the incorporation of work-integrated learning (WIL), such as internships, into programs of study. The most effective way to carry out work-integrated learning is to engage with real industry problems; for statistics students, this can be achieved within a capstone unit that brings together the various skills and knowledge that they have developed throughout their studies. In this paper, we describe our developing collaborations with industry for our Statistics and Decision Science students, and provide examples of industry projects on which they worked.*

### INTRODUCTION – GRADUATE EMPLOYABILITY AND INDUSTRY-FOCUSED LEARNING AND TEACHING

A tertiary education in statistics comprised solely of theoretical courses is no longer seen as adequate by learners and teachers alike. Students are more willing to spend time learning statistics when they are able to apply it practically and to see how it will be useful to them professionally. Today's 'millennial generation' students are reported to prefer collaborative learning, including learning from their peers, and focusing on authentic problems (Turner 2016). In applied statistics courses, students are able to apply what they learn in classes to problems at hand; in other words, they are learning by *doing* (Kolb 1984) rather than learning only theoretically. In addition, if they participate in work-integrated learning they are also addressing and solving authentic problems.

From the other side of the pedagogic process, employers are increasingly demanding that students have workplace skills: soft skills, such as teamwork, communication, problem-solving (FYA 2016), leadership (Safian 2012) and experience in working with real data and real problems. In other words, they are placing increasing emphasis on graduates who are *work-ready* (PhillipsKPA 2014) as well as knowledgeable about the theoretical aspects of their discipline. Governments, too, increasingly focus on graduate employability, with funding implications in many countries (Husbands 2017; Dougherty et al. 2016). The Australian Government requires universities to gather data about their graduates as part of 'quality indicators for learning and teaching' (QILT 2016). This then informs international rankings such as the QS Graduate Employability Rankings (QS 2017).

Strictly speaking, our students' learning might not fit the traditional definition of WIL, which requires students to experience day-to-day life in workplaces. Some of our students were required to attend workplaces to carry out their projects due to sensitivity of data; others had initial face-to-face meetings and then acquired the data or design specifications and worked from campus or home, communicating with clients via email, skype or telephone. These arrangements are typical of those that we see in professional statistical consulting work, so all students experienced some form of real working conditions when they were carrying out their projects. While the definition of WIL may be problematic, the requirement for *authentic* tasks is not. Based on Oliver's (2015) WIL map, our students would be classed in *high level WIL* (top right quadrant), the highest possible WIL. Further, our unit satisfied the pedagogical requirements listed by Orrell (2011, pp 2) for a WIL curriculum (students knew what was expected of them, the projects were challenging, they needed to reflect on their experiences and learning and they had opportunities to show their leadership).

Work-integrated learning (WIL) during higher education is becoming part of many disciplines and university courses to improve the work-readiness of graduates. In this paper, we will present the university-wide WIL framework used in our university and provide three case studies from a capstone unit for students majoring in Statistics and Decision Science. Our

experiences of designing and implementing the capstone unit might help new starters to avoid some of the pitfalls that we faced, and to design effective courses and create successful collaborations.

#### WORK INTEGRATED LEARNING AT MACQUARIE UNIVERSITY – PROFESSIONAL AND COMMUNITY ENGAGEMENT (PACE)

Macquarie University's approach to include work-integrated learning into the curriculum was an institution-wide curriculum renewal that began in 2008 and required each undergraduate degree program to include a Professional and Community Engagement (PACE) unit of study. As in almost every country, teaching, health-related disciplines such as psychology and chiropractic, and engineering already had such units in their curriculum; however, there was no coordination of such activities across the university. Prior to 2008, each department or faculty organised their own students' placements, internships or practicals for such activities. Full implementation of the initiative, with a policy change to require each undergraduate student to complete a PACE unit during their degree, was completed in 2015.

Institutionally, there were major investments to implement PACE, including a new central PACE office where strategic decisions could be made, strategic partnerships created, international partnerships developed and the whole range of activities monitored. In addition to the central PACE administration, each faculty set up their own PACE offices with academic and professional staff to support lecturers convening PACE units. This support includes sourcing partners and activities, and monitoring students while they are off campus. Some policy changes regarding the workloads associated with PACE units were also initiated through a university-funded research project (Clark et al. 2016), so that PACE unit convenors are allocated extra time to cater for activities unique to such units (such as legal agreements and partner- and student-related tasks).

In 2017, there were 88 PACE units across five faculties, with over 2,500 partners, and including 25 countries where international PACE activities were hosted for Macquarie University students (PACE 2017b). The success of the project is attested by the fact that Macquarie University won the *2017 Australian Financial Review Higher Education Award for Employability* and was highly commended in the *2017 Association for Tertiary Education Management Best Practice Awards for Community Engagement*. As well as sourcing and setting up projects, PACE (2017a) requirements include supporting participants throughout the process, and assisting partners and students to reach a mutually beneficial outcome. In this context, the Department of Statistics chose to create a final-year capstone PACE unit (Bilgin et al. 2011) focusing on statistical consulting.

In response to curriculum changes in 2008, we designed a unit, *Statistical Consulting*, to fulfil both the capstone and PACE requirements. The unit included review and contextualisation of statistical material from previous years, applied in the context of real problems sourced from workplace and community settings. Professional skills such as team work, communication both verbal and written, and conflict resolution were interwoven into the course. We ran our unit for the first time in 2011 with nine students (Bilgin et al 2011, Bilgin & Petocz 2013). We initially sourced the student projects from within the university, from academics and postgraduate students in other departments, such as computing and education. The University Senate accredited *Statistical Consulting* as a PACE unit in 2012. In 2013, students worked on a range of professional staff projects, such as an analysis of previous years' career fair data, aimed at measuring its effectiveness and suggesting improvements, and academic staff projects, such as evaluating the effects of recent developments of 'active learning spaces' on campus.

In 2014, Macquarie's international PACE office organised a project for our students with an international non-governmental organization (NGO) located in India and running a project from Zimbabwe. Students were reluctant to volunteer for this project, possibly due to logistical issues – no face-to-face meetings were possible, and the data seemed very messy. We (the lecturers) chose two of the most able students to work on this project. These students organised three-way Skype meetings with the partners to sort out the data quality problems and then a two-way Skype meeting towards the end of the semester to present their findings before they finalised their report. Both the students and the partner were well satisfied with the results of the project.

The following year, 2015, we extended the unit to the Decision Science major, changing its name to *Consulting in Statistical Sciences*. By that time, most projects originated from off campus, through the faculty PACE office, and we continued to include projects from our international

partner in India. We also initiated a collaboration with social science students in two projects: the impact of a sport initiative on school attendance and engagement in at-risk primary school students, and housing affordability in a local council area near campus. Both these projects were sourced by the Faculty of Arts PACE team, but required statistical design and/or analysis of collected data – which our students were well placed to provide. On another project, our students collaborated with environmental science students to design a computer program to predict the impact of climate change on a business, using the *R* statistical software and *R* packages; the partner, a commercial organization, was impressed with the work the students produced. In 2016, only two of the 11 projects were from within the university, with the majority of the projects sourced from our existing partners by the faculty and international PACE offices. Over the years, we have observed a decline of academic workload related to sourcing partners for the projects, since we have developed and maintained relationships with industry partners, and the Faculty PACE office actively finds new partners for our students. However, with the increasing number of students and the projects, academic workload related to assessment keeps increasing (Bilgin et al. 2017).

### CASE STUDIES – STUDENTS’ WORK WITH PARTNERS

#### *An international project for an NGO located in a Developing Country*

This was a major project undertaken in 2015, which investigated the prevalence of gender-based violence in two slum areas of Delhi, India, from the viewpoint of three different groups: school students, parents and community leaders. The cultural values of this country are very different from Australia’s, and therefore a session on cultural differences (Hofstede 2015) between different countries was designed by the International PACE office and integrated into the curriculum. This was a baseline study for understanding attitudes and behaviour regarding gender-based violence among young people and their parents prior to running education programs for them.

This project gave students a rich experience of involvement with, and deep insights into, a foreign culture. Working from campus rather than in the host country was the only feasible approach practically. Students chose to work in groups of two or three, rather than individually, on this project when they realised the nature of the data – multidimensional and quite messy, with variables not well defined and many missing values – and a specialist from Macquarie’s Learning Skills office talked to them about effective group work. Student groups reported spending up to 80% of their time understanding the variables and preparing the data for analysis, with the remaining 20% of their time spent on the analysis, mainly descriptive statistics and visualisation. Although writing reports and preparing presentations intimidated students at first, the authentic problem context helped them to develop these complex skills rapidly and naturally. Students were asked to submit a draft of their project a few weeks before its due date; this was read by two of us and returned with constructive feedback, which all groups incorporated into their final reports. The findings were presented to the partner at a Skype meeting. Each group’s final report was graded by two lecturers as if reviewing a research paper, and then a moderation meeting was used to decide on a final grade. Each report was shared with the partner, to demonstrate the different approaches to the problem, and each was accompanied by the lecturers’ comments on its strengths and weaknesses.

Possibly the best aspect of this project for students was to learn that their statistical skills were useful to improve the lives of young people in a developing country. Their reports were not filed away or recycled after the completion of the unit, but used by the partner for marketing of youth education programs and designing future studies.

#### *Optimisation of Work Schedule in Call Centre*

In 2016, a group of three students undertook a project to optimise the work-scheduling process for a call centre operated by a large financial company. The students combined multiple technologies to deliver a user-friendly scheduling product. The client’s requirement was to determine the optimal staffing levels for its call centre, balancing the costs of overstaffing against the danger of slow service and customer frustration. They provided a de-identified and incomplete sample of call log data, as well as a description of work scheduling considerations, such as minimum acceptable shift lengths, lunchbreak requirements and staffing costs.

The students began by analysing the call data to produce a probabilistic model of the demand process, including call frequency as a function of time of day, call duration distribution, and typical balking time (that is, how long customers are willing to wait on hold). Using these estimates, they wrote a program in *R* to simulate a day of call centre operation under any given staffing regime and evaluate it according to the two criteria (staffing costs and service quality). In principle, they then had a function that they could optimise to produce the best staffing schedule. In practice, the space of feasible staffing schedules was complicated and very high in dimension, presenting, at best, an extremely challenging optimisation problem. To provide a satisfactory solution within the timeframe and the team's expertise, they developed a heuristic solution. They divided the day into half-hour blocks, used their simulation code to determine the optimum staff level within each block, formulated an integer program to seek the feasible staffing schedule most closely matching the half-hourly optima, and then solved the integer program using *Excel Solver*.

Because the students were using modified data, and because usage patterns are subject to change, the client needed to be able to replicate the students' solution. Therefore, the final component of their work was a simplified user-interface, developed in the *Shiny* platform for *R* apps, making it very easy for the client to feed new data through the same process to obtain new optimised schedules. This was a relatively strong group, with two of the three students enrolled in Macquarie's prestigious Actuarial program. Despite that, we were impressed with the outcome. The client was also very satisfied; the students were invited to present their work to the CEO, and were featured in the company's internal newsletter.

Ideally, a capstone project should give students a chance to apply the technical skills acquired in earlier units of study in a practical way. It was gratifying to recognise technical elements of the students' approach from their earlier learning – the queue simulation, adapted from our second-year computer simulation unit, and the integer programming, covered in our third-year operations research unit. On the practical side, the team showed excellent judgement in their heuristic approach, which allowed them to provide a *good* solution, complete and on time, rather than an unfinished but otherwise perfect solution. Further, they demonstrated a mature client focus in going to great lengths to develop a clear and intuitive user interface.

#### *Evaluating the effects of public transport service changes*

One of the projects undertaken in the 2017 offering focused on the public transport system in the university's local area, the suburb of Macquarie Park. Macquarie University is the nucleus of a major research and technology district, and is adjacent to the largest shopping centre in New South Wales. It is a major public transport hub, with up to 12 000 train and bus passengers per day passing through the suburb. The train line running through Macquarie University will be closed for a major upgrade for most of 2019. The client for this project was a local transport infrastructure advocacy group wanting to understand current usage patterns and the impact of the service interruption, to inform recommendations to the University, other local employers, and the transport authority.

This consultation was addressed in two stages. At the beginning of the semester, as an individual assessment, each student performed their own analysis of local bus usage data for two recent work weeks. This provided a variety of perspectives to the client, helping them to formulate more specific research questions. Student reports identified daily and weekly patterns of transport demand, relative demand at all bus stops in the area, usage demographics such as ticket type, and the other suburbs whence/whither passengers travel to/from Macquarie Park.

For the second phase, a group was formed from four students who had performed particularly well in the initial assignment. It was expected that more data might be available for this stage, but the client was unable to obtain them for student use. The two five-day periods were a little over eight months apart, confounding any analysis of trend and seasonality. Nevertheless, the student group independently sourced and cross-referenced with other publicly available data sets on the locations of bus stops and train stations and the boundaries of suburbs and postcodes, in order to provide a detailed analysis. The students used state-of-the-art geographic information systems software in order to provide map infographics of a very professional quality, which we expect will be useful to the client in stakeholder communications.

This project gave the students an excellent opportunity to go beyond applying knowledge they already had, and to seek out suitable methods and technologies to best meet the client's goals. It was gratifying for the students (and lecturers) to work on a project with a tangible, local, public impact. Lastly, the two-stage format of the project allowed all students to contribute, and gave one group of students a longer working relationship with the client (almost the whole semester).

## DISCUSSION AND PEDAGOGICAL IMPLICATIONS

### *Benefits for students*

There are many potential benefits for students undertaking work-integrated learning. Problem authenticity encourages a higher level of engagement and challenge, aspects that are identified as key to success of WIL projects (Orrell 2011). Students work with complicated, messy data sets of a sort rarely seen in university courses, but ubiquitous in real-life statistical practice. The problems encountered – as in real practice – tend to be less well defined than the clear, didactic examples seen in traditional units. Thus, in WIL students learn practical, modern data-handling skills, and how to draw out clients about their real data analysis goals, in a supported classroom context.

A particular aspect often unexpected for most students is the degree to which simple and straightforward statistical methods can be used to address complex problems. Students have often reported that they 'did very little actual statistics', but sorting out the definition of categories of a variable, or preparing a graphic to summarise a context and suggest a solution are important aspects of real statistical practice. One student wrote as advice to future classes: "sometimes the simplest solution is the best solution, and I guess that would hold true for jobs outside of university too."

Workplace experience also gives students insight into the employment market, helping them to clarify their career options. The networking aspect is particularly valuable. In some cases, graduates have gone on to further internships or employment with the PACE partners. Many of our projects involve students working to advance the wellbeing of people and the planet. One of the most important benefits for students is the opportunity (indeed, requirement) for critical reflection on their own and their peers' learning during and after their consulting experiences. This is another aspect of WIL that is identified as essential by studies (Orrell, 2011).

### *Workload considerations for academics*

Academics' responsibilities in assessment and administration are certainly higher in WIL units, due to the many relationships to set up and manage, and the heterogeneity of the student work. Academics (and students) report that they find project-based learning more effective, but also more time-consuming. WIL thus represents a greater investment in exchange for better educational outcomes. However, the additional workload required can be a barrier or an unfair burden to staff wishing to implement such an approach to learning, unless they are given credit for the extra workload and administrative support for the necessary arrangements – as is the case at Macquarie.

The extramural networking required to source and manage WIL projects may have positive spin-offs for academics' research careers, especially in environments emphasising the social and economic impact of research. A successful PACE partner relationship may lead to joint supervision of postgraduate research projects, or other more substantive research collaborations.

### *Other implementation considerations*

In our experience, group work is an essential ingredient in the success of this kind of unit. When students work in groups, they help each other to keep the project progressing and to complete it on time, and the variety of perspectives and group discussion lead to stronger outcomes than the students could produce individually. In the seven offerings to date, only once has a project not reached a state of satisfactory completion, and that was the one time we allowed a student to attempt a project alone. Of course, group work does come with a risk of tensions, but managing these working dynamics is a valuable learning goal. Occasionally, group relationships break down and then the situation must be handled tactfully and sympathetically, for instance, by allowing a group to break into independent subgroups each with specific aims. At the same time, it is

important to point out to participants that such accommodations may not be possible in a real work situation!

Students should be encouraged to include a complete record of the steps in their work, including data preparation and cleaning, analysis, and productions of plots and tables. For students using *R* or other scripting environments, the simplest way to do this is to include their code in an appendix. Easy reproducibility has important benefits that may not occur to less-experienced students, such as allowing them to quickly accommodate new information or better understanding in the final stages of the project, and helping the client to carry out similar statistical work in the future.

Confidentiality is frequently an aspect of WIL projects, in our unit and in some other PACE units at Macquarie. We exploit an economy of scale by handling confidentiality agreements, as much as possible, through the PACE offices. In particular, before semester begins, our PACE office provides invaluable administrative support in liaising with partners, obtaining initial descriptions of the projects, and effecting legal and institutional requirements.

Much of the class time is devoted to ‘life-long learning’ skills, advanced research methods, effective written and oral communication, and aspects of career and professional preparation. The discussion of ‘becoming a statistician’ (Petocz & Reid 2010) is a set reading and always provokes lively discussion. One student’s reflections summarise this aspect: “Working in a consulting group really gives us a structured experience so we can practice skills applicable to professional situations. This experience has given me a chance to prepare better for my professional future.”

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