WORK INTEGRATED LEARNING IN DATA SCIENCE AND A PROPOSED ASSESSMENT FRAMEWORK

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ABSTRACT

Work integrated learning (WIL) has been the norm in disciplines such as medicine, teacher education and engineering, however it has not been implemented until recently in statistics and not for every student in computer science education. There seems to be no literature on the use of WIL for data science education. With the changed focus of universities to making graduates "job ready", university-industry collaboration widened to encompass learning and teaching. Undoubtedly authentic problems coming from industry created opportunities for students to practice their future profession before graduation. This shift in the curriculum, however, brought its challenges both for the students and their lecturers. In this paper, we present a case study and propose an assessment framework for data science WIL.

Keywords: *Statistics education research; Data science education; Work integrated learning; Authentic problem-based learning; Assessment framework*

1. INTRODUCTION

The landscape and focus of higher education institutions are changing. Governments (Bolton, 2019) and universities (Macquarie University, 2021; The University of Edinburgh, 2017; The University of Sydney, 2021; University of London, 2021) around the world have been re-shaping higher education institutions' pedagogy by prioritising (soft) employability skills along with discipline-based learning. Learning the facts and skills required for a profession are no longer sufficient and acceptable by employers. As a consequence, universities are ranked based on their students' employability (QS Top Universities, 2020; THE Student, 2020). Traditionally, some degree programs, such as medicine, engineering and teaching, relied on placements, internships or work-based experiences before students completed their degree in order for the degree to be accredited with the relevant professional bodies. From the Science, Technology, Engineering and Mathematics (STEM) disciplines, engineering was an exception that required work integrated learning (WIL). Most statistics and mathematics degrees do not incorporate WIL, while in computing some degree of WIL was already in the curriculum, especially when accreditation required it, but WIL is not always offered to every student. Pricewaterhouse Coopers' (PwC) 23rd Annual Global CEO Survey, involving 1,581 chief executives, reported that "The skills organisations need today—creativity, problem solving, an understanding of how digital technology can be used—and in the future are a moving target" (PwC, 2020, p. 16). This statement implies that giving students opportunities to practice workplace desirable skills during their studies is as crucial as teaching them discipline-based knowledge.

In 2017, one-third of Australian higher education students had a WIL experience where one in five of these (23.3%) were project work (Universities Australia, 2019). The variety of WIL activities provides unique learning experiences for students including placements, field work, simulations, industry panels, and project work. These provide authentic work-based learning opportunities for

Statistics Education Research Journal, 21(2), Article 12. https://doi.org/10.52041/serj.v21i2.26

students and opportunities for academics to learn the trends in industry. The challenge is designing assessment tasks that enable rigorous and fair assessment, especially when students work in groups. Furthermore, Edwards et al. (2015) stated that "gaps in our knowledge of WIL include the way in which it is assessed" (p. 10). Similarly, there is a gap in the curriculum framework provided for data science in the report by the International Data Science in Schools Project (IDSSP) (2019). The report provides details of which topics should be included in the curriculum, how to design learning materials for the topics and learning outcomes but it neglects providing any guidance on assessment. Given that data science is an emerging area, it is important to have an assessment framework for data science WIL.

Data science is different from statistics since it is embraced by many disciplines, unlike statistics that mostly remains in the domain of statistics discipline. Especially, computing academics are leading the developments of data science, despite the outcries of statisticians. An example of contentious developments is newly designed *Data* Science degrees and/or major with very limited statistical courses such as only having one or two statistics courses where all the remaining courses offered on computing. Two of the authors of this paper are academics in computing and statistics departments. We had various exchanges over the years teaching statistics WIL and Computing WIL to our students. This paper brings our experience and knowledge together to contribute to data science education. We hope that this paper will provide guidance on designing assessments for data science students, whether they are taught by computing academics or by statistics academics or by academics from any other discipline.

The American Statistical Association (ASA) (2014) published curriculum guidelines for undergraduate programs in statistical science, which included more diverse models and approaches to assessment; however, those guidelines do not provide any indication of how WIL can be assessed. Smucker and Bailer (2015) documented their attempt at assessing student learning in a statistics capstone unit (which is similar to WIL), where students worked on real client projects, and highlighted the difficulties of assessing individual student contributions to group work. Obtaining projects from industry for statistics students to work on has been identified as a challenge (Jersky, 2002; Mackisack & Petocz, 2002; Martonosi & Williams, 2016). It is possible that obtaining projects for statistics students are harder than obtaining projects for other disciplines because there are shortages of statisticians, which has persisted for some time (Alexandria, 2015; Moran, 2004). Therefore, it is harder to find industry supervisors who can formulate problems as statistical problems in industry. Being an emerging field of study and practice, data science, which requires statistical and computing skills is prone to similar problems like statistics when it comes to supervision of students by industry partners. There is a need to provide possibilities and guidance for educators to implement WIL in their institutions for the benefit of their students being "job ready" after graduation, and for educating industry partners to think statistically.

A WIL alternative to the internship is placing students in self-managed student teams to conduct industry projects within organisations. This alternative aligns with expectations of employers to develop graduate attributes such as time management, teamwork, and communication skills. Industry-based projects that expose students to a client's problem have additional benefits of providing authenticity in terms of designing an approach to solving the problem and identifying knowledge and skills required for the solution. It also gives opportunities for students to exercise ethical and professional behaviour among team members and with the industry partner (Richards, 2009). Furthermore, they provide the opportunity for assessments that are authentic, contextualised and divergent, the latter allowing more creative and diverse learning experiences (Biggs, 2011). Despite recognition of the value of WIL for improved learning and work-readiness, guidance on designing and sourcing suitable projects and what and how to assess students is lacking particularly in new areas of study/majors, which includes data science. This newer major has proven to be very popular in our university resulting in large enrolments but meeting the demand for WIL for students in the data science major is particularly problematic due to its newness (it takes time to build new relationships), the nature of the resources needed for projects, and the increased risks associated with accessing organisational datasets or networks.

In this paper, we present a case study from our university for a WIL unit in Data Science Major (Section 2) and propose an assessment framework for data science WIL based on our experience over the past decade with WIL units (Section 3). The discussion (Section 4) and conclusion (Section 5) synthesises the benefits and challenges for obtaining projects from industry, delivering valuable outcomes for industry partners, ensuring optimal learning outcomes for students, and assessment of WIL for data science. Our proposed assessment framework could be used for data science education to guide future WIL planning and assessment design for data science programs, which are missing from IDSSP (2019).

2. CASE STUDY

2.1. BACKGROUND

With the Australian government announcement that all Australian university funding growth will be linked to universities producing job-ready graduates through the Commonwealth Grant Scheme (Department of Education, Skills and Employment, 2021), Australian universities are under increasing pressure to find innovative ways to prepare their undergraduate students for the modern economy. Since 2011, our university has been preparing all undergraduate students for the workforce by giving them the opportunity to engage with an organisation on an authentic project through its Professional and Community Engagement Program (PACE) (Macquarie University, 2021). The university provides this opportunity by offering at least one compulsory PACE unit, which comprises an academic framework and a WIL activity, in every degree (Clark et al., 2016).

The need for evidence-based decision making by organisations has grown substantially over the last decade. It is our expereince that a growing number of organisations have access to data but do not have the skills to analyse their data to create evidence for their decisions. Therefore, the opportunity of offering a highly valued skillset to industry has presented itself for students majoring in statistics and data science. Incorporating real-life projects into student learning can give small businesses, non-governmental organizations (NGOs) and research organisations an opportunity to have undergraduate students design studies, analyse their data, produce reports, and answer further questions the organisation(s) might have.

Assessment tasks play an essential role in ensuring students gain the intended knowledge and skills. In Australian higher education institutions, it is very common for STEM disciplines to have 50% or more of the assessments within a session as low stake quizzes, assignments or class tests based on the previous few weeks of learning. The remaining 50% is a final exam at the end of the session. Although essays are highly utilised in social sciences, STEM students rarely write anything more than one or two pages for their assessments. They learn to write conclusions based on their experiments/analysis (usually a paragraph or so) or explanations of how their computer program would work, but very rarely write a complete report or complete documentation of an IT project. When students' progress to the third year, they are planning their careers, therefore, what they learn and how they are assessed in the third year are crucial to ensure a successful transition from university to industry. This transition can be facilitated via participation in a WIL unit.

Assessments determine what students prioritise to learn in a regular unit (Ramsden, 1992). Therefore, they look at previous offerings of a unit and try to get previous assessments and solutions to shape their learning. In a WIL unit, this strategy is not helpful to students because, depending on which project they work on, the discipline knowledge that they need to use is likely to be different from earlier projects and the projects that their peers are working on in the same session. The main aim of WIL units is to provide an opportunity for the students to apply their discipline knowledge to solve a real problem(s). Therefore, it is important to help students to understand how they will be assessed (Boud, 1998). One of the best ways to do that is to give students a rubric or a marking guide relevant to each assessment task, as early as possible in the session. Examples of previous students' work (e.g., project reports, presentations) may also be helpful. However due to confidentiality of many WIL projects, that might not be possible.

It is very common to have project report/s and presentation/s as assessments when students work on an industry project. Ideal assessment tasks scaffold project management of expected outcomes by assessing project plans and providing constructive, timely feedback to draft projects to ensure that promised outcomes are delivered to partner organisations. This scaffolding also helps students to work on their project throughout the session instead of just a few weeks before the session ends. Assessment tasks also need to provide opportunities for students to develop report writing and presentation skills that might be useful as part of their portfolio or in a job interview, since these skills are highly valued for professional work (Cameron et. al., 2017). Acting as consultants within WIL projects may also give students an entrepreneurial experience, which can lead to students experiencing what it would be like to be self-employed.

The data science unit is a 3rd year unit that "draws together learning in previous units to prepare students for the workplace through engaging with a partner organisation" during one learning session which consists of 13 weeks of classes and 2 weeks session break in the middle (COMP3850 Unit Guide, 2022). There are no weekly set topics to be learned since the projects are different and students' previous learning should guide them to apply their knowledge to a given problem. If new skills are needed to be learned, students work with their academic and industry supervisor to identify best resources for their individual learning

2.2. LEARNING OUTCOMES AND STRUCTURE OF UNIT

Learning outcomes in our data science unit include critically analysing a given problem, identifying the steps to solve such a problem, recognising and addressing ethical issues when they arise based on an understanding of professional ethics, and finally producing a solution to the problem that needs to be communicated to the problem owner both as a report (written communication), and by a presentation (verbal communication). In our unit, students are given ownership of their projects from the beginning to the end. They make decisions to convert the presented problem to a statistics or data science problem, since the project usually comes in layman terms and the research question(s) and expected outcomes are not clearly articulated by industry partners. The first step for students is clarifying research question(s) or preparing the scope of their project, which needs to be approved both by industry partners and by academics. Through this process, students also consider ethical issues related to their projects. Where ethical issues occur during the WIL/PACE activity, students can feel invested in resolving or mitigating these issues. During the session, academics discuss examples of ethical dilemmas past students have encountered as well as ethical issues that students might be experiencing in their projects. Academics act as mentors to empower students to feel confident to address ethical issues with their industry supervisor(s).

On committing to a project and prior to commencing, students agree to completing all background checks, attending workplace inductions and any other professional requirements of the organisation. Students also agree to the university code of professional conduct whilst working with partner organisations (e.g., inclusion of a Working with Children Check). Meeting and understanding that all of these requirements are an important part of working in a profession prepares students for employment prior to them leaving university and builds their resumes.

Through taking the responsibility of the delivery of a complete project, students are given opportunities to learn or improve their leadership, teamwork, time management, project management, communication and negotiations skills. The WIL/PACE consultancy project gives students a context in which they use problem-solving skills to deal with ambiguity, develop assertiveness (e.g., by asking questions), resilience (e.g., by accepting feedback), and experience a real-life opportunity to develop a realistic expectation of what it is like to work in the professional discipline they have chosen. Through inclusion of assessable journals and/or a final report, our students follow reflective practices to record and evaluate their progress, which provides them with a safe and non-judgemental opportunity to learn how to articulate their professional and self-development journey.

2.3. EXAMPLES OF PROJECTS

Our first example includes students' reflections on a project where they were required to convert an existing paper-based data collection system to a digitised collection system supported by a back-end database for a charitable organisation. As one student stated, they were motivated by their awareness that "working with an organization whose responsibility is to save the lives of swimmers at Australian beaches gave all team members a chance to create something for the improvement of society." Throughout the project, the student team worked closely with their industry supervisor to better understand what was expected from them and to validate their outputs. They were able to deliver a solution, which helped the charitable organisation to better serve the community and save resources, time, and money. As one student said,

> *The broader community is better served through safer beaches, safer carnival events and hopefully, lives saved as a result of more accurate decision making.*

In a group report students wrote,

> *We had all adequately learned the theory behind project development, but never before had any of us been able to practically apply the knowledge that we had learned. We were able to link this theoretical knowledge up to producing a cohesive project, with real value for a client. Towards the end of the project all team members were in agreement the PACE project allowed us to feel ready to join the workforce as professional technologists.*

As a group, they acknowledged the value of weekly meetings and effective open communication within the team members over the full term of the project to overcome difficulties, such as technical challenges, thus ensuring the expected outcomes be produced. The way students approached this project from the beginning helped them to achieve their aim, which as one student elaborated:

> *We decided that we would not simply treat the project as another university assignment. We treated the project as we would a genuine employed position and invested ourselves in it accordingly. The clear benefits that our project was offering to society enabled all team members to become truly invested and passionate about the quality of our work.*

One further example of a project was a proof of concept where the students created an app for a local government to identify frog calls to support management of endangered species through monitoring population movements. Two other examples were delivery of detailed data analyses to support an NGO's grant application, and an analysis of *Facebook* data to identify user engagement with a policy change an NGO was trying to implement. Students have also worked with private organisations on projects to assist with decisions on insurance and public organisations seeking information on water quality, which resulted in a journal paper being written where the students were credited with the initial data analysis work.

2.4. TYPES OF ASSESSMENT TASKS

The WIL unit for the data science major in our university is offered by the Computing Department. In keeping with outputs and terminology in the IT industry, assessments in the unit are known as deliverables (D0-D8). Each assessment task with their weights can be seen in Table 1. The first assessment task (D0) is participation in the *Working in Teams Workshop*. The first deliverable (D1) is a feasibility report submission after students meet and talk with their industry sponsor (partner). The feasibility report requires students to clarify the problem; discuss the opportunities and mandates; identify the success factors; describe the current situation; explore possible alternative solutions; recommend a solution and outline the tangible and intangible benefits of their proposed solution. The feasibility report is followed by a project plan (first part of D2) where students document the purpose and scope of their project; risk management; resource management; a Gantt chart showing planned tasks, deliverables, timeline, resource/task allocations for the entire project; and a quality manual clarifying how the team will communicate, assure quality, resolve conflict, and manage change. The second part of D2 is to document requirements/scoping for the project where students are advised to use the CRoss Industry Standard Process for Data Mining (CRISP-DM) (Chapman et al., 2000). Deliverables 3 and 4 are incremental submissions that build on D2. Deliverable 5 is the final group reflective report with sections that include group and individual reflection together with a review of Deliverables 2–5, which are iteratively refined to cover requirements, analysis and design, as well as testing and implementation.

During the session, students are provided with opportunities to present their progress on the project in a formative way. At the end of the session, students present their work to academic(s) and project owners from industry (D6). This enables students to practice their presentation skills, which are highly valued in the workplace. It is expected that each group member presents some aspect of their project by describing the problem being addressed, what they did to address the problem, and how they went about coming up with solutions. In addition to demonstrating their solution and approach, the presentation is also expected to include reflections on the project and processes used, recommendations on what could be improved and suggestions of future/outstanding work. Students are reminded that solving a problem is great but being able to explain how the problem was solved and how outcomes could be implemented in a workplace is as important as the solution. Therefore, project reports and presentations include details to help industry partners know what to do with the proposed solutions.

Table 1. Assessment structure of the unit and their weight of the final mark

Assessment Task	Content	Weight (%)
Deliverable 0 (D0)	Participation in Working in Teams Workshop	1
Deliverable 1 (D1)	Feasibility Study	7
Deliverable 2 (D2)	Project Plan + requirements/scoping document Students follow CRISP-DM as a guide.	7+6
Deliverable 3 (D3): Increment 1	Updated D2 documents + design documentation + test documentation + Prototype/MVP	13
Deliverable 4 (D4): Increment 2	Updated D2 documents + updated D3 documents + user / training manual	13
Deliverable 5 (D5)	Final Group Reflective Report	8
Deliverable 6 (D6)	Project presentation and demonstrations	10
Deliverable 7 (D7)	Delivery of product to industry partner	10
Deliverable 8 (D8)	Final Exam	25
Total		100

To enhance the sense of belonging and enable networking, the opportunity for the students and industry supervisors attending an evening event to gather at the university eatery after the presentations is promoted. This gives industry supervisors a chance to thank and socialise with their students, as well as celebrating the completion of the project.

At the end of the session, industry supervisors, following handover of the final product, assign a mark for the project (D7). A final exam is used to assess the conceptual understandings of students and how they applied these concepts to their projects (D8). Examples of questions in the final exam are:

1) Consider principles of ethics and describe how they were relevant to your project and how they have prepared you for your career.
2) Why is quality important and how is it relevant to your project? How did you manage and assure quality?
3) Describe what strategies were used in managing the team and the industry partner. In your answer discuss what needed to be managed and give examples of issues and how they were resolved.

A team or consultancy model gives students a sense of ownership and responsibility for their projects. Ensuring students work together within their group helps to clarify any unclear or ambiguous information or expectations before approaching their industry supervisor for help. In our unit, students generally worked in two separate teams, as “consultants” on the same project, providing their partner organisation with two “different” proof of concept solutions to a data science/IT problem. Given that our unit has large cohorts of students (n > 200) and offered twice a year, allocating two teams on one project ensures that each team has a project to work on and ensures partner organisations receive “something of value.” The two-team model is also used for assessment calibration and to ensure that any problems with teams or partners can be identified. In addition, as teams are multidisciplinary, project solutions can be very different.

3. PROPOSED ASSESSMENT FRAMEWORK FOR DATA SCIENCE WIL

Authentic projects used in WIL are complex, usually ill-defined, and require performing complex tasks (e.g., modeling, writing a computer program, designing a study) instead of easy selection of existing solutions. Real-life problems have additional complications such as not having a pre-determined solution or ways of solving the problem(s). They require construction or application instead of recall or recognition and they are student-centred, not teacher-centered (Muller, 2006). Designing assessments for such projects requires five dimensions to be considered: 1) task, 2) physical context, 3) social context, 4) result/form, and 5) criteria (Gulikers et al., 2004). Using these five dimensions, we discuss what needs to be considered for designing data science WIL assessments based on our decade long experience with our unit. For each dimension of the framework, we synthesise what is relevant and needs to be considered for a good assessment.

Tasks need to be meaningful and relevant to students' study. Although obtaining real projects is challenging, especially in the earlier implementation of a data science WIL unit, due to lack of resources (e.g., professional staff support) and/or lack of industry connections, it is possible to start with projects sourced within a university from academics, higher degree research students or university units such as a career office or library. Regardless of where projects come from, they need to be screened by academics to ensure that they are relevant to students' prior learning. If projects are suitable, then students need to be given ownership of projects under supervision (either by project owners or by academics) so that students experience what it means to practice their profession after university.

Physical context of the experience includes availability of the resources, such as software and access to a workspace (for internships); time pressures associated with professional life; and various risk assessments. All organisations providing a project need to be screened by academic or professional staff to ensure they are legal entities, hold the necessary insurance, and commit to inducting and hosting students for the duration of the activity. For projects in data science, risk assessments such as discussions and agreement on the de-identification of data, discussions on Intellectual Property rights, whether students require background checks (e.g., police checks, Working with Children checks, confidentially agreements) could be done by students. Nowadays, most of data scientists and statisticians work as consultants who have their own workspace but visit the organisations they work with. Therefore, although some organisations only accept interns due to highly confidential data, others are willing to give their data to students after signing a confidentiality agreement, which enables students to work wherever they prefer.

Social context of professional practice should be considered to decide whether project work and related decisions could be done individually or as a team. Undoubtedly, most of the time, data scientists, similar to statisticians, work in collaborative multidisciplinary teams and they rarely work alone. Therefore, it is beneficial to balance assessments with individual and teamwork assessments. Because authentic projects from industry are complex and require synthesising prior learning and possibly learning new skills and unknown software or techniques, sharing the responsibility of delivering a solution to an industry partner by a team will reduce the burden on any individual student. Additionally, teamwork on projects will improve students' teamwork skills, ensure the delivery of a report and a presentation, and reduce the risk of not delivering the project even if some members of a team decide to withdraw from the unit or are unable to contribute due to unforeseen circumstances. Therefore, it is important to identify each student's contribution to teamwork by using individual assessments such as self and peer assessments, and self-reflections to eliminate the possibility of "freeloaders" benefiting from teamwork and ensuring the fairness of the assessments. Furthermore, reflections on the learning process, including reflections on team dynamics and technical problems, is beneficial for students to gain lifelong learning skills, which are useful after graduation.

Result/form requires students to demonstrate their competence by applying their discipline knowledge, solving industry problems and presenting their solutions. For a data science WIL unit, that includes a project plan, a project report and presentation(s). A project plan ensures that students are addressing the problem presented by an industry partner and avoids the errors of the third kind (Kimball, 1957). An error of the third kind is defined by Kimball (1957, p. 134) as "the error committed by giving the right answer to the wrong problem" and "caused by inadequate communication" (p. 135). A project report is needed to document and communicate students' solution(s) and how solution(s) could be used by industry partners. Presentation to peers and industry partners, helps students to improve their (oral) communication skills and give opportunities for peers and industry partners to ask questions to clarify any grey areas. All of the assessments, from plan to presentation, could be divided into increments that enable academics and industry partners to provide feedback for continuous improvement before a final set of documentation and solution(s) are created. This incremental assessment ensures the solution fits the partners' needs and provides opportunities for students to reflect on and improve their understanding.

Criteria used for assessing students in a WIL unit should be similar to real workplace performance assessments and expectations. To ensure that students in a data science WIL unit, understand what is expected of them and deliver a valuable solution to industry partners, assessment documents need to include details of what is expected in each assessment task along with a rubric to describe levels of possibilities. Some assessment types, such as self-reflections are very valuable for WIL units (Richardson et al., 2009), however, it is more than likely, it will be the first time during their studies that students are assessed on their self-reflections. Rubrics and/or marking guides and, where possible, previous students' work can be made available to the students. The disparate nature of projects requires flexible rubrics so that different projects can be assessed fairly. In a regular unit where students are answering the same questions as part of their assignments, quizzes or in final exams, there is usually only one correct answer. However, working on real problems is very different to working on set assessment questions. Real problems require creative thinking, problem formulation and solving, and synthesising the knowledge from academic learning and industry expectations to be able to write a report for industry partners. Until students create a solution, which could be suggested by the industry partners, there is no (worked out) solution to the problems. Rubrics help students understand how they are going to be assessed and enable academics to be consistent when marking various kinds of projects (Dawson, 2017). From an academic perspective marking creative work for real problems is harder than marking a set of questions with known answers, since ensuring consistency of marking is harder, takes longer to mark, but is also exciting and fun to mark (e.g., each project is different, and similar to a small thesis or industry report).

Our assessment tasks addressed what were explained above as important aspects by Gulikers et. al. (2004)'s five criteria. The *tasks* were carefully chosen from available industry projects by academics to ensure that they were relevant to what students were studying and able to do within a study period. The students were given access to required resources (such as software) to be able to undertake their projects (*physical context*). The assessment tasks were broken into individual and teamwork components to reflect the professional practice and to ensure student learning can be fairly assessed (*social context*). The incremental assessments of learning provided opportunities for reflection and improving the *results/form* while acting as a professional data scientist. Assessment rubrics provided to the students at the beginning of their project work ensured that *criteria* of each assessment task were clear and clarified what is expected to be included in assessments (such as reports).

4. DISCUSSION

The aim of this paper was to propose an assessment framework for data science WIL to fill the gap in the data science education literature (Edwards et. al., 2015) and/or available resources/guidelines such as IDSSP (2019) and the ASA curriculum guidelines (2014). A case study was presented in section 2 where background information, learning outcomes, examples of projects and types of assessments from our unit was explained in detail. Five dimensions of authenticity for assessment by Guilkers et. al. (2004) were used to identify the aspects that are important to be considered and included at the assessment design (Section 3). These five dimensions are *tasks, physical context, social context, result/form,* and *criteria*.

We argued that the authenticity of *tasks* can be achieved by real industry problems so that students practice being a professional consultant and gain the required (soft) skills (PwC, 2020; Richards, 2009). Although obtaining projects from industry is a challenge (Martonosi & Williams, 2016; Mackisack & Petocz, 2002; Jersky, 2002), with the increased use of online meeting tools, software access and transformed understanding of working from distance during to COVID-19 pandemic, it is becoming easier. Therefore providing a *physical context* for industry based projects is as easy as offering classes face-to-face on campus. Due to the imperfect nature of industry problems, ideally students work in teams; however, teamwork assessments need to be balanced with individual assessments to ensure fairness and acknowledgement of contributions or lack thereof (Smucker & Bailer, 2015). Our unit uses various types of assessment task (Section 2.4) so that a balance can be achieved between individual and team-based tasks. These can be adapted or adopted by data science academics and/or teachers. The artifacts of the WIL experiences are professionally written project report(s) and presentation(s) (*result/form*). These are not just assignments which could be forgotten about, they are valuable inclusions in future job applications and can be referred to during job interviews for answering very common questions like "*How do you deal with pressure or stressful situations?", "Do you have experience in leading a team or working in a team?*", as well as providing diverse learning experiences (Biggs, 2011). Knowing the *criteria* of assessments (Boud, 1998) helps students to prioritise their learning (Ramsden, 1992). As well, *criteria* help academics to ensure consistency of marking therefore it is important to create holistic rubrics for each assessment, and maybe more details and examples are needed when unfamiliar assessments such as self-assessments (Andrade, 2019) and reflections (Clarà, 2014) are used.

5. CONCLUSION

Obtaining projects from industry is not an easy task and it has many dimensions and associated paperwork. Based on our experience, most academics are not trained and few wish to be involved in completing such tasks. Therefore, having professional staff who can assist academics with such tasks are crucial for the success of setting up any WIL unit. Regular (de)briefing of professional staff ensures that the processes and systems for screening and onboarding of partner organisations is kept abreast of the pressures and the complexity of industry. In the initial stages of setting up a WIL unit, working within a university with partners from the university will be useful to keep the risks to a minimum (e.g., unsuccessful projects will not cause reputational damage to the university).

WIL units aim to provide valuable outcomes for industry partners and enable academics to link with industry. For students, WIL units provide opportunities to experience what it is to work in industry by acting like consultants during their studies and to *think*, not *just do* as it might be in an internship where students are given bite-size projects to work on without seeing the big picture. In such internship situations, students are rarely given opportunities to make decisions.

WIL experiences allow students to learn professional skills, work on real and often imperfect data, and feel that they are contributing to an organisation, instead of just "ticking an assessment box." Acting as "consultants" gives them ownership, leadership, and the role of the expert within the safety of a unit of study (Bilgin et al., 2018). In the larger industry context, the consultancy model often more closely aligns to the use of agile processes, such as the Scrum Model (Schwaber, 1997), which further prepares students for the collaborative and team-based model many organisations want future employees to adapt to and work within. Through a WIL unit, students learn that career opportunities exist in many organisations, not just in big companies. They learn the importance of teamwork and experience the frustrations of real-life problems while being expected to manage these pressures by acting as professional consultants. WIL projects also increase students' employability in a competitive market, as they give students an experience to speak to in an interview, a referee for their resume, and a report that they can add to their portfolio. This model can also be used under COVID-19 restrictions, since students can work with their supervisors from industry online throughout their project.

Through WIL, most students experience their first real life discipline-based project within the context of a university unit which provides a "safe space" for them to learn and practice the professional skills that they need in industry. Working on an authentic project can be very challenging for students, as it is most likely the first time, they are taking on the role of an "expert" in their discipline. Academics can supervise and support students when they experience challenges that stretch them in unexpected ways, giving them strategies to deal with various issues which might be encountered. Students learn what it is like to work in an organisation, be it an NGO trying to make a difference or a for-profit industry company, or even a start-up. They learn what it is like to work within a highly structured organisation, or possibly an organisation that has little structure. Students also have the opportunity to network with their cohort and learn from the experiences of other students.

In STEM disciplines, students rarely practice their public speaking skills. Given that many people are fearful of public speaking, and some people fear public speaking more than death (Burgess, 2013), helping students to be good presenters needs to be an essential part of a WIL unit. Having weekly meetings with the group members and regular meetings with industry partners help students to become comfortable presenting their ideas and build their confidence for presenting to larger audiences, such as their project presentation to the whole class.

The interactions between academia and industry through a WIL unit provide opportunities to informally gather data on industry trends and problems, as a contrast to the more traditional Industry Advisory Committee. Working with industry partners enables universities to identify the needs of industry for curriculum development, since academics learn from partners what is valued in industry. In a sense, they can act like a defacto advisory committee. By including all academics within a department to the end of session WIL presentations, all academics can be kept up to date, and they can show their support to students while building relationships with industry.

Reflection is an important part of WIL assessments. Often the reflections revolve around the ethical and professional questions which arise from real-life activities. Such ethical dilemmas are difficult to replicate in a textbook scenario. Students working on a "real life" activity tend to have a deep sense of ownership and responsibility for their project, because they have to report to an external supervisor who has a status and influence on students, which is completely different from any experience a textbook or academic can replicate. Student reflections can be used to capture the professional and personal growth this unique experience often leads to. Student reflections also offer a great source of information for academic staff as the reflections can reveal the real pressures and opportunities that organisations face. By working directly with students and partner organisations, WIL academics could learn more about discipline issues within industry and use this experience to inform the development or enhancement of further teaching, be it in the discipline area or in the career development area.

Students' interactions with industry are a very important part of WIL units. They are not just working on an authentic project from industry; they are working with industry partners on an authentic project. They learn to discuss feedback from industry supervisors within their group and then make decisions and pose solutions in a relationship that is different from the usual student-academic exchange. Through interactions with industry supervisors, students learn about ethics and professionalism by experiencing real ethical problems, practice professionalism and connect their learning to the theory they are being taught in the classroom. Students learn to play the role of an employee, or consultant, in a real workplace that is "safe" due to the support academics offer by providing feedback to (draft) assessments (i.e., project report) and during class discussions. The proposed assessment framework supports the project management of the activities as well as enabling students to engage with industry supervisor(s).

In addition to successful delivery of a prototype or proof of concept solutions or reports of analysis of data to industry supervisors, there could be a number of other valuable outcomes. Working with undergraduate students with discipline specific skill sets enables organisations that might not have the capacity or skills to achieve certain goals that they would not otherwise be able to achieve. The independent/consultancy team model is an opportunity for industry partner staff to develop their own client management skills as they can reverse roles and take on the role and perspective of a client to a team of student "consultants". In both small and large organisations, giving a staff member the responsibility of meeting, motivating, and supporting students is an opportunity for their staff to try out their management potential and skills. Working with students who often bring fresh ideas, great enthusiasm, and curiosity could be inspiring and motivating for industry supervisors. Many industry supervisors that we worked with enjoyed "giving back" to young developing professionals and saw this as an opportunity that they would have liked to have been given, however, it was not available to them.

Teaching ethics and professionalism in isolation to students working on a real project is not as valuable because it remains in a vacuum. When learning about ethics and professionalism, students are able to put their learning into action which allows them to be constructive in their learning (they can connect their learning to their experiences).

Assessing learning through WIL experiences has been identified as problematic (Richardson et al., 2009) when academics assessed the students as if they are assessing any other unit of study. Furthermore, Bilgin et al. (2017) reported that WIL academics' workloads usually are not acknowledged within their universities workloads since there are hidden workloads, which usually spread across an academic year. In this paper, we presented a case study and proposed an assessment framework for data science WIL, which may help to create fair assessments, rubrics for assessments, and may help reduce the academic workload for developing such units.

ACKNOWLEDGEMENTS

We thank our industry partners for providing us with the projects and giving their time to work with our students. We also thank our students who work on the problems and provide solutions to real, authentic problems—we wish them success in their careers.

REFERENCES

Alexandria, V. A. (2015, October 1). More students earning statistics degrees, but not enough to meet surging demand for statisticians. *American Statistical Association News*. https://www.statsoc.org.au/resources/Documents/Career/2015-StatsDegreeGrowth.pdf

Andrade, H. L. (2019). A critical review of research on student self-assessment. *Frontiers in Education, 4*. https://doi.org/10.3389/feduc.2019.00087

American Statistical Association. (2014). Curriculum guidelines for undergraduate programs in statistical science. https://www.amstat.org/asa/files/pdfs/EDU-guidelines2014-11-15.pdf

Bilgin, A. A., Rowe, A. D., & Clark, L. (2017). Academic workload implications of assessing student learning in work-integrated learning. *Asia-Pacific Journal of Cooperative Education, 18*(2), 167–183.

Bilgin, A. A., Bulger, D., & Petocz, P. (2018). Industry collaboration through work-integrated learning in a capstone unit. In M. A. Sorto, A. White, & L. Guyot (Eds.), *Looking back, looking forward. Proceedings of the Tenth International Conference on Teaching Statistics* (ICOTS10), Kyoto, Japan, July 8-14, 2018. International Statistical Institute. https://iase-web.org/icots/10/proceedings/pdfs/ICOTS10_5D3.pdf?1531364271

Biggs, J. B. (2011). *Teaching for quality learning at university: What the student does*. McGraw-Hill Education.

Bolton, R. (2019). University funding to be tied more toproducing students who get jobs. *Financial Review, October 2, 2019*. https://www.afr.com/policy/health-and-education/university-funding-to-be-tied-more-to-producing-students-who-get-jobs-20191001-p52wkz

Boud, D. (1998). Assessment and learning: Unlearning bad habits of assessment. Presented at the *Effective Assessment at University Conference,* Brisbane, November 4–5. https://nanopdf.com/download/page-1-of-12-5b1385fcd50e8_pdf

Burgess, K. (2013, October 30). Speaking in public is worse than death for most. *The Times.* http://www.thetimes.co.uk/tto/science/article3908129.ece

Cameron, C., Iosua, E., Parry, M., Richards, R., & Jaye, C. (2017). More than just numbers: Challenges for professional statisticians. *Statistics Education Research Journal, 16*(2), 362–375, https://doi.org/10.52041/serj.v16i2.196

Chapman, P., Clinton, J., Kerber, R., Khabaza, T., Reinartz, T., Shearer, C. & Wirth, R. (2000). *CRISP-DM 1.0 Step-by-step data mining guide.* The CRISP-DM consortium. https://www.the-modeling-agency.com/crisp-dm.pdf

Clarà, M. (2015). What is reflection? Looking for clarity in an ambiguous notion. *Journal of Teacher Education, 66*(3), 261–271. https://doi.org/10.1177/0022487114552028

Clark, L., Rowe, A., Cantori, A., Bilgin, A., & Mukuria, V. (2016). The power dynamics and politics of survey design: Measuring workload associated with teaching, administering and supporting work-integrated learning courses. *Studies in Higher Education*, *41*(6), 1055–1073. https://doi.org/10.1080/03075079.2014.966071

COMP3850 Unit Guide. (2022). *COMP3850 PACE: Computing Industry Project.* https://unitguides.mq.edu.au/unit_offerings/150505/unit_guide

Dawson, P. (2017). Assessment rubrics: Towards clearer and more replicable design, research and practice. *Assessment & Evaluation in Higher Education, 42*(3), 347–360. https://doi.org/10.1080/02602938.2015.1111294

Department of Education, Skills and Employment. (2021). *Job-ready graduates package.* https://www.dese.gov.au/job-ready

Edwards, D., Perkins, K., Pearce, J., & Hong, J. (2015). *Work integrated learning in STEM in Australian universities: Final report.* Office of the Chief Scientist, Australian Council for Educational Research. https://research.acer.edu.au/higher_education/44

Gulikers, J. T. M., Bastiaens, T. J., & Kirschner, P. A. (2004). A five-dimensional framework for authentic assessment. *Educational Technology Research and Development*, *52*, Article 67. https://doi.org/10.1007/BF02504676

International Data Science in Schools Project Curriculum Team. (2019). *Curriculum frameworks for introductory data science*. http://idssp.org/files/IDSSP_Frameworks_1.0.pdf

Jersky, B. (2002). Statistical consulting with undergraduates: A community outreach approach. In B. Phillips (Ed.), *Proceedings of the Sixth International Conference on Teaching Statistics* (ICOTS6), Cape Town, South Africa. International Statistical Institute.

Kimball, A. W. (1957). Errors of the third kind in statistical consulting. *Journal of the American Statistical Association*, *52*(278), 133–142. https://doi.org/10.1080/01621459.1957.10501374

Mackisack, M., & Petocz, P. (2002). Projects for advanced undergraduates. In B. Phillips (Ed.), *Proceedings of the Sixth International Conference on Teaching Statistics* (ICOTS6), Cape Town, South Africa. International Statistical Institute.

Macquarie University. (2021). *Employability.* https://www.mq.edu.au/study/why-study-here/employability

Macquarie University. (2021). *Professional and Community Engagement program (PACE).* https://students.mq.edu.au/study/course/pace

Martonosi, S. E., & Williams, T. D. (2016). A survey of statistical capstone projects. *Journal of Statistics Education*, *24*(3), 127–135. https://doi.org/10.1080/10691898.2016.1257927

Moran, S. (2004, July 3). Statistician shortage starts to bite. *Australian Financial Review*. https://www.afr.com/search?text=Statistician+shortage+starts+to+bite.+

Mueller, J. (2006). Authentic assessment toolbox. http://jonathan.mueller.faculty.noctrl.edu/toolbox/whatisit.htm#looklike

Pricewaterhouse Coopers. (2020). *PwC's 23rd annual global CEO survey: Upskilling: Building confidence in an uncertain world.* https://www.pwc.com/gx/en/ceo-survey/2020/trends/pwc-talent-trends-2020.pdf

QS Top Universities. (2020). *Graduate employability rankings 2020.* https://www.topuniversities.com/university-rankings/employability-rankings/2020

Ramsden, P. (2003). *Learning to teach in higher education*. Routledge.

Richards, D. (2009). Designing project-based courses with a focus on group formation and assessment. *ACM Transactions on Computing Education (TOCE)*, *9*(1), 1–40. https://doi.org/10.1145/1513593.1513595

Richardson, J., Kaider, F., Henschke, K. & Jackling, B. (2009). A framework for assessing work integrated learning. In H. Wozniak & S. Bartoluzzi (Eds.), *The student experience*, Proceedings of the 32nd HERDSA Annual Conference, Darwin, 6–9 July 2009 (pp 336–345).

Schwaber, K. (1997). Scrum development process. In J. Sutherland, C. Casanave, J. Miller, P. Patel, & G. Hollowell (Eds.), *Business object design and implementation* (pp. 117–134). Springer. https://doi.org/10.1007/978-1-4471-0947-1_11

Smucker, B. J., & Bailer, A. J. (2015). Beyond normal: Preparing undergraduates for the work force in a statistical consulting capstone. *The American Statistician*, *69*(4), 300–306, https://doi.org/10.1080/00031305.2015.1077731

THE Student. (2020, November 19). *Graduate employability: Top universities in the United States ranked by employers 2020.* https://www.timeshighereducation.com/student/best-universities/graduate-employability-top-universities-united-states-ranked-employers-2020

The University of Sydney. (2021). *Careers and employability*. https://www.sydney.edu.au/business/study/careers-and-employability.html

The University of Edinburgh. (2017). *Employability*. https://www.ed.ac.uk/employability

Universities Australia. (2019). Work integrated learning in universities: Final report. https://apo.org.au/sites/default/files/resource-files/2019-04/apo-nid242371.pdf

University of London. (2021). *Global employability*. https://london.ac.uk/global-employability

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