# Interdisciplinary work-integrated learning: Australian university project-based learning pilots and practices

MARGO BREWER[1]
*Curtin University*, Perth, Australia
SALLY LEWIS
*University of South Australia*, Adelaide, Australia
SONIA FERNS
*Curtin University*, Perth, Australia

Work-integrated learning (WIL) has become an essential component of many university curricula. Recent global disruptions have challenged traditional models of WIL, particularly industry-based student placements, leading to growing calls for new, sustainable models of WIL. Aligned with this call and the increased emphasis on learning across disciplines, interdisciplinary project-based WIL provides an alternative to student placements that is both student and industry centered. This study reports on the outcomes of pilots of this model of WIL across four Australian universities. A cohort of 38 students, faculty and industry staff who participated in the pilots were interviewed. The key challenges and enablers of interdisciplinary project-based WIL are identified along with recommendations for implementation.

Keywords: Interdisciplinary, project-based learning, work-integrated learning

Work-integrated learning (WIL) is essential to prepare students for work readiness in a disrupted employment market that requires new and diverse graduate capabilities. The workplaces of the future require professionals who can navigate ambiguity, be productive in globally distributed teams, and negotiate solutions using sophisticated interpersonal and technical skills (World Economic Forum, 2018). Furthermore, many of the issues facing society are complex problems that require interdisciplinary solutions (Ramaley, 2014). Davies et al. (2011) describe the ideal worker as "someone with a deep understanding of at least one field but the capacity to be conversant in the language of a broader range of disciplines" (p. 11). Successful graduates need complex problem solving capabilities, as well as entrepreneurial mindsets and skills (Foundation for Young Australians, 2020).

Responding to this changing world of work, contemporary higher education has a greater focus on employability than ever before. Oliver & Jorre de St Jorre's (2018) review of university graduate attributes noted an increased focus in recent years on information literacy, global citizenship, problem solving, and interdisciplinarity. Students are also more focused on employability with growing expectation that their university qualification will equip them for the world of work (Lasen et al., 2018).

WIL is directly aligned with employability as it can enhance not only disciplinary knowledge but also the development of key graduate skills including problem solving, verbal and written communication, interpersonal communication, teamwork, leadership and negotiation skills, self-esteem, confidence, and work readiness (Lim et al., 2018; Smith & Worsfold, 2014). Recent turbulent events are limiting the ability of universities to continue to sustain and scale traditional WIL pedagogies such as industry-based placements (Zegwaard et al., 2020). Several researchers (e.g. Brassler & Dettmers, 2017; Hart,

[1] Corresponding author: Margo Brewer, M.Brewer@curtin.edu.au

2019; Lim et al., 2018; Piggott & Winchester-Setto, 2020) claim, interdisciplinary project-based WIL is an effective alternative to placements that benefits both students and employers.

Interdisciplinary project-based WIL prepares graduates for the contemporary world of work where complex problems demand solutions drawn from multiple disciplines and employers increasingly requiring collaboration skills (World Economic Forum, 2018) as super-structured, matrixed organizations continue to rise in popularity (Davies et al., 2011). Project-based learning requires that projects are complex, based on challenging contemporary questions or problems, involve students in the design, decision making, problem solving and investigation, provide students the opportunity to work relatively autonomously over an extended period of time, and culminate in realistic products or presentations (Thomas, 2000). This experiential learning lends itself to engagement with industry to ensure students are addressing real-world problems (Repko et al., 2019). Working through the projects with faculty and industry, students develop essential entrepreneurial, problem solving mindsets and skills for work readiness (Brewer et al., 2020).

The increasing focus on demonstrating attainment of employability skills, often leveraging WIL pedagogies, raises the importance of educators understanding, sharing, and embedding innovative practices into the curricula (Brewer et al., 2020). Embedding any new approach to WIL in the curriculum requires an appreciation of the challenges and enablers. To further the research within the higher education sector into interdisciplinary project-based WIL as an alternative to work placements, this study aimed to develop and pilot test project-based learning at four Australian universities. The pilots, scaffolded by a theoretical framework of social constructivism (Rannikmäe et al., 2020), employed a variety of learning pedagogies with implications for the deployment of important design considerations and changes in teaching practices. A brief overview of each pilot follows. For a more detailed description of the pilots, and a guide to interdisciplinary project-based learning, see Brewer et al. (2020).

## PILOTS

Four Australian universities representing different states across the Australian Technology Network conducted interdisciplinary WIL pilot projects in 2019/20. The pilots involved students in later years of their degrees from the health, humanities, Science, Technology, Engineering and Math (STEM) and business disciplines. A total of 34 faculty, 19 industry staff and 265 university students participated in the pilots. Inclusion criteria were: (1) faculty currently teaching one or more units with a WIL component, and/or direct involvement in management of WIL; (2) industry staff willing to work with the university on an industry-based project; and (3) students enrolled in a unit taught by a staff member participating in the pilot projects.

### *Curtin University Pilot*

Curtin worked on an industry-based project with Lab Tests Online Australia. Students from marketing, media and graphic design, and data analytics participated in the project. Detailed evaluation of the industry partner's website included analysis and consumer surveys to improve performance for the user and optimize search engine capability. The website's visual design was assessed and revised to increase impact and address literacy issues. Students also developed a social media marketing plan for industry.

*University of South Australia (UniSA) Pilot*

The UniSA pilot brought together students from communication, marketing and digital media to develop a social media campaign to increase Apprentice and Trainee participation for the South Australian Department for Innovation and Skills. Working in small teams, the students co-designed and developed an industry standard communication plan complete with campaign prototypes. Design thinking methodology was employed, enabling students to apply their disciplinary knowledge and skills in developing solutions to the client challenge. Delivered fully online the pilot was supported by inbuilt pedagogical tools and discussion forums that enhanced opportunities for collaborative learning while an online tutor provided oversight and individualized feedback on the campaigns.

*RMIT Pilot*

Students from human resources, marketing, and accounting participated in the RMIT pilot, which had three industry partners: The National Tertiary Education Union; JobCo, and Specialisterne. The students worked in interdisciplinary teams to investigate future work trends and prepare recommendations on challenges relating to career pathways, organizational culture and workforce diversification. The pilot incorporated a group pitch strategy where students refined their industry research project and presented their approach to the industry partners. The resulting reports provided viable solutions and potential pathways to address the identified challenges.

*University of Technology Sydney (UTS) Pilot*

The UTS pilot engaged students from engineering, information technology, design, architecture and building in interdisciplinary, project-based studios to create design solutions for real-world problems. The students participated in projects including designing livable cities, tackling global warming, re-conceptualizing healthcare solutions using medical devices, and designing community spaces with Indigenous and community stakeholders. Applying design thinking skills, the students worked in teams to ideate solutions, validate stakeholder needs, develop prototypes and test early-stage designs. Sharing multidisciplinary knowledge, the students utilized a wide range of technologies including data analytics, robotics, math modelling, sensor design, artificial intelligence and machine learning, quantum computing, augmented reality and space applications.

## OBJECTIVES

This multi-site, exploratory project focused on identifying the impact that participation in the pilot projects had on the follow:

1. Faculty's knowledge and capacity to develop and implement interdisciplinary project-based WIL,
2. Industry partners' attitudes towards interdisciplinary project-based WIL,
3. Industry partners' attitudes towards collaboration with the university, and
4. Students' perceptions of employability skills and interdisciplinary project-based WIL.

## METHODS

An exploratory case study was utilized as it allows the study of the social phenomena of WIL in its original context (Mills et al., 2010). Furthermore, the research design was qualitative to allow for identification of rich, in-depth themes in relation to the participants' knowledge, capacity and attitude/perception (Braun & Clarke, 2006).

*Participants*

From the total pool of 318 project participants, as outlined above, a total of 19 university students and 13 faculty from a range of courses across health, business, humanities and STEM participated in an individual interview or focus group. In addition, six industry staff also participated in an interview. Tables 1, 2 and 3 summarize the demographic information of interview and focus group participants across the three cohorts, students, faculty and industry staff.

TABLE 1: University students demographics.

| Characteristics | | University Students ($n$ = 19) |
|---|---|---|
| Gender | Male | 4 |
| | Female | 15 |
| | Not Specified | 2 |
| Year Level | 1 | 0 |
| | 2 | 3 |
| | 3 | 15 |
| | 4 | 1 |
| Course | Integrated Communication Planning | 9 |
| | Future of Work | 6 |
| | Data Science | 1 |
| | Marketing | 2 |
| | Internal Communications | 1 |
| Study Mode | Domestic | 12 |
| | International | 7 |

TABLE 2: Faculty demographics.

| | Characteristics | Faculty ($n$ = 13) |
|---|---|---|
| Gender | Male | 8 |
| | Female | 4 |
| | Not Specified | 1 |
| Years of University Teaching Experience | 0-5 | 2 |
| | 6-10 | 5 |
| | 11-15 | 3 |
| | 16-20 | 2 |
| | 21-25 | 1 |
| Years in Current Role | 0-5 | 9 |
| | 6-10 | 0 |
| | 11-15 | 1 |
| | 16-20 | 3 |
| Currently Teaching | Undergraduate (UG) | 6 |
| | Postgraduate (PG) | 1 |
| | Both UG & PG | 2 |
| | Managing, not teaching, WIL | 4 |

TABLE 3: Industry staff demographics.

| | Characteristics | Industry Staff ($n$ = 6) |
|---|---|---|
| Gender | Male | 1 |
| | Female | 5 |
| Size of Enterprise | Small (0-19) | 1 |
| | Medium (20-200) | 2 |
| | Large (200+) | 3 |
| Years Collaborating with Universities | 0-5 | 5 |
| | 6-10 | 0 |
| | 11-15 | 0 |
| | 16-20 | 1 |

*Data Collection and Materials*

A semi-structured interview guide was developed for each participant group to allow for the collection of interviews (faculty and industry staff) and focus group data (university students). The faculty guide explored the project's impact on their attitudes towards interdisciplinary project-based learning, and their confidence and knowledge of facilitating interdisciplinary project-based learning. The industry guide explored the project's impact on their attitudes towards interdisciplinary project-based learning, and their experiences collaborating with the university. Finally, the student guide explored how participation in the project impacted their attitude towards employability skills and interdisciplinary project-based learning, as well as their project learning experiences. Each interview ranged from 30 to 60 minutes in duration. The focus group was 90 minutes in length. A research assistant was employed at each university to undertake this data collection.

*Procedure*

Ethics approval was gained from Curtin University's Human Research Ethics Committee (HRE2019-0430-01) along with approval from the other three participating universities' ethics committees. Faculty were informed of the project during both formal and informal meetings with project team members. E-mails to students, faculty within the relevant schools, and industry partner organizations invited them to register their interest. Participants were provided with an information sheet that outlined the details of the study and their contribution. Signed consent forms were obtained for all participants. Audio recordings of the interviews were transcribed verbatim.

*Data Analysis*

Thematic analysis was conducted to allow for the collection of in-depth, rich data, analyzed to explore emerging patterns, as well as organizing the text into inclusive themes that addressed the overarching research questions and objectives (Braun & Clarke, 2006). To begin the analytical process, the interviews were read repeatedly, and initial topic codes generated through working line by line and collating the data relevant to each code (Braun & Clarke, 2006). These topic codes were constructed into analytical codes, reflecting preliminary interpretations and versions of the potential themes identified; relevant exemplar quotations were also noted (Braun & Clarke, 2006). These potential themes were further refined, to ensure they were representative of the data; as such, each theme was then titled and defined (Braun & Clarke, 2006). Finally, the themes were written up, related back to the research literature, and produced in this paper (Braun & Clarke, 2006). Member checking was also adopted where participants were invited to provide feedback on the representativeness of the key

messages that were common within interview data and the interpretations of these ideas.

## RESULTS

Given the similarities between the perceptions of faculty and industry staff, the results for these two cohorts are integrated. Students' perceptions are reported separately.

### *Faculty and Industry Staff*

Four themes were identified from the interviews with faculty and industry staff: the application of learning to real-world contexts, a broader approach to thinking and doing, interdisciplinary project-based WIL as a transformative pedagogy, and academia versus industry.

#### *Application to the real-world*

Faculty suggested that engaging in interdisciplinary project-based WIL allowed students to assimilate and integrate their diverse knowledge to real-world contexts. By engaging in this form of learning, students were able to work together to resolve authentic issues identified by industry. For example, one participant stated: "How I structure the project is very much around a challenging task that requires peer cooperation and learning to facilitate and do it." Further to this, participants expressed how these issues reflect what occurs in the workplace: "Working on any real-world project is giving you [the student] a much more genuine work experience."

The issues identified by industry must be specific for authentic experiences to occur. In comparison to ill-defined or contrived project scopes, Faculty identified that this specificity allowed an engaging process for all involved, which results in students: "Being able to navigate the process, being engaged, and transferring the knowledge to apply it in a way that helps build an understanding of the problem and its solutions". Faculty noted that by addressing real-world issues students were motivated to learn "it's natural to include project-based learning within that [the curriculum] because it enables more student-driven learning." In addition, students' increasing autonomy was evident as they took responsibility for their learning and demonstrated emerging leadership skills.

Faculty viewed this style of learning as preparing students for the professional world as many of the skills they developed during the projects were applicable to workplace tasks. For example: "Working in a team setting, being able to have their opinion heard, considered, being able to contribute in that professional context, receive the feedback from industry and then be able to apply that moving forward". Overall, engaging in an interdisciplinary project was a valuable experience for students: "Project-based learning helps to provide that kind of setting, that kind of almost workplace setting so that they can learn those skills. So very valuable."

Industry staff also acknowledged that the project allowed for real world application of learning to the workplace. The projects required assimilation, integration and personalization of how knowledge is transferred to other contexts, problems, or issues: "It helps convert theory into reality through practice. Sometimes when you're just dealing with theory, it's easy to come up with a lot of really interesting ideas, but unless it's grounded in reality, they're never going to work."

Industry staff acknowledged that part of their role within the project was to 'light the fire', acting as the catalyst to discussions surrounding real-world problems: "We put forward an issue and then students worked on our problem and they presented us with some different ideas". Industry staff noted that these complex problems required students to work together to figure out solutions. The role of industry

was thus one of providing an authentic context, clearly articulating the problem and then allowing the learning to take place. As for faculty, the authenticity of the learning experience was a key feature of project-based WIL: "It's a practical approach to things that they [students] might actually have to deal with in employment…this gives them really some good skills in how to address that stuff." The need to produce something that helped resolve the problem was a key element of the learning: "It's not just about getting the reports for us, it's about passing on the knowledge and producing an end product." The importance of students' post-project reflections was highlighted by industry staff: "Reflecting gives them some ideas about what working life will be like and what the possibilities are and how their skills can be used."

*A broader approach to thinking and doing*

By engaging in this style of learning, faculty felt the students reflected on how they had been taught and began to view knowledge from a different theoretical lens: "Students take a step back and look at what others have done and then try to apply a different mindset to it…they can find a different angle to tackle a problem." These new perspectives, constructed through students adopting critical thinking skills, were facilitated through the interdisciplinary process. Critical thinking was viewed as fundamental to the learning process by faculty: "They'd be able to develop their creative thinking, critical thinking skills as well… being able to think outside the box a little bit, that's so crucial."

Industry staff identified that by engaging with students during the project, they were able to gain a new perspective on the issue to be solved: "To get access to people with young minds and people with up-to-date specialty in terms of learning." This new perspective was achieved by harnessing the students' agile minds whilst giving them new experiences within the project and within industry. Finally, industry staff viewed the process as assisting and preparing the students for the professional world, "…you use your real experience to guide you through the workplace."

*A transformative pedagogy*

Faculty acknowledged the difference between interdisciplinary project-based learning and more traditional educational pedagogies:

> More traditional forms [of education] are about question and answer. You provide some content, get them to hopefully do the reading, come up with some correct answers, tick them off and so on. Whereas this is more about, they control their own learning… personally, it's more interesting to engage that way for students than doing a very traditional class structure.

Faculty felt this approach to learning challenged their own thinking, whereby how teaching had been done previously was questioned: "Just being able to look at something in a little bit of a different way, you start to think, oh, we didn't think about it quite that way." Reflection on their educational practice included recognition of the need for greater engagement with industry problems: "We can find ourselves in a bit of an academic bubble sometimes…instead of sitting back and taking an academic approach, it actually gets us to engage with real-world problems." Adopting this new form of learning, faculty were able to adopt transformative practices to use in the classroom: "You have to have the confidence to go forward and try new things. Build new skills. Try and find solutions, and then use them with your students."

Industry staff also reported engaging in reflection in relation to how they participated in the process: "Sometimes we reflect which allows us to reposition what we're thinking and so sometimes that's a good thing to bring about change." Interdisciplinary project-based learning transpired as a catalyst for

shifting the mind-set of industry partners, thereby enhancing their capacity to enrich student learning and work in partnership with academic staff.

Faculty viewed their role within project-based WIL as a shift to being 'a guide on the side', assisting students to work autonomously. This role included facilitation of discussions among students and between students and industry, and guiding students through any difficulties experienced: "It's very much more of a mentoring role, a support mentor, guidance as opposed to being a teacher…if they're having trouble communicating with their client [industry partner] or working as a team that's where your role comes into it." Faculty highlighted the importance of avoiding giving students specific step-by-step instructions. Furthermore, faculty suggested their role was to facilitate students developing multiple perspectives; guiding the construction of knowledge that surpassed notions of right and wrong solutions. Instead, students were guided away from dichotomous thinking to reflect on how the problem/project might be managed within a real-world context.

Finally, faculty acknowledged the value of interdisciplinary learning with several commenting that no one discipline could solve the complex problems provided by industry. Rather, the move to adopting more than one perspective was nurtured through the interdisciplinary process: "The problems that we're dealing with are so complex that one field isn't going to be capable of problems that are worth solving."

*Academia versus industry*

While the role of industry partners was acknowledged, there was contention among faculty as to the value of industry involvement. Some viewed the industry role as vital: "I think it's great for faculty to be working with industry … Just to see what is, what is possible." Other faculty felt the academic role was more valuable: "I think the problems were a little bit too focused on what the industry wanted but it didn't really fit in with the course. That's where the academic role comes in; it's a lot more fundamental I think". Regardless of the value placed on these roles, faculty were aware of the importance of industry involvement in posing the 'wicked, tricky' problem that needed to be resolved, setting the standard of the project outcome, and adopting a mentoring role with the students:

> I think they [industry] would tend to give guidance in terms of this is the kind of standard we want, these are what our needs are…they have the role of mentoring to ensure the student's learning outcomes, negotiated with them, are being met.

Industry staff also acknowledged tension during the pilots. In reflecting on the start of the project, industry staff members expressed a level of uncertainty in agreeing to take part in the project. They acknowledged a lack of clarity over who was going to be involved and what the project would actually entail in terms of workload and tasks to complete: "To start off with how to craft the project was very nebulous. I didn't really understand what it was the students were doing or what we would be doing". Misalignment between industry's needs and the requirements of academia was another contributing factor. At the outset, industry staff questioned the utility of the experience and what the final product could look like: "I think perhaps my expectations were a little unrealistic…the ideas were ones we had thought of in the past or trialed in the past that were not really practical for the actual [university] setting". Reflecting on the amount of work and input they had within the project, some industry staff felt their role was not as valued or visible as the academic role: "I don't think very many people involved in the project actually know how much effort I put in with behind the scenes…a lot of that just fell under the radar". Further, industry staff felt they were the ones making compromises: "You just had to be completely flexible and go, "Oh, okay so I won't get that, but I'll get this, and I didn't

really ask for it, but let's see where it goes".

Faculty suggested that the overall process of engaging in interdisciplinary project-based WIL facilitates the formation of mutually beneficial links between stakeholders: "I think it creates that nexus between academia, community, civil society and industry…it is substantial in making those connections in some way to improving the practices in those organizations. So, it's a mutual benefit". While the engagement with industry process was identified as taking a lot of time and investment, the benefits appeared to outweigh inputs, with some acknowledging welcome unanticipated outcomes:

> So, that wasn't my aim going in, to network and make connections, but it's just been a nice outcome that's come out of it. Developing those relationships with the other academic supervisors and the industry partners, getting to know the students and just seeing what they can do. That's pretty inspiring.

Additionally, by ensuring project-based WIL addressed real problems faced by industry, the relationship between the university and industry was nurtured. For example, a faculty member commented: "Whatever the students create has to have value for the organization, so that they are drawn to doing it again." Unanticipated benefits identified by the industry staff, included stakeholder connections: "Being able to make and facilitate social networks and connections with the students, faculty, and industry partners". Furthermore, industry staff felt they were now privy to elements of academia that they would not normally see in their usual interactions with the university, knowledge that will be of use in future collaboration with the university sector. Many of the industry partners involved in the pilots were interested in participating in further collaborative projects. They reflected that their experience in the pilots confirmed their confidence with the project-based learning approach: "I'd come away from this project being enthusiastic about it, where we want to continue with a new lot of students next year…we think it has been useful and we'd like to continue."

*University Students*

Three themes were identified from the interviews with students who participated in the four pilots: the importance of being open to new interdisciplinary experiences, building employability skills, and enhancing industry.

*Open to new interdisciplinary experiences*

Students acknowledged the importance of going into the experience without preconceived ideas, ready for the opportunity provided to them. They articulated demonstrable benefits of learning from one another during project-based WIL, most of which related to learning with students who had different skill sets and perspectives: "I do normally work within teams but having people from different skill sets was different to me. So, working collaboratively within the team, facing the challenges together, overcoming the challenges and everything like that was really cool." The opportunity to work on different components of the project and come together to collaborate was useful, as it allowed multiple perspectives to emerge, "You've got to embrace everyone's opinions and thoughts and be open minded about it…even if we didn't agree at first, we'd find a solution and yeah, it worked out well." Building collaborations enabled achievement of the outcomes of their projects. Further, the students suggested that the project-based approach required them to 'come out of your shell' and find a way to contribute. As a result, the ability to communicate across disciplines was viewed as an important component of the experience. Students suggested being flexible within the experience, and to move beyond their own way of thinking to embrace everyone's perspectives was critical to the success of project-based learning..

*Building employability skills*

Students recognized the relationship between the project, interdisciplinary teamwork and employability (engaging in professional practice). Reflecting on their experience with navigating the project, students saw the alignment with future work: "I'm doing some work that I could possibly be doing once I finish my studies." Further, being able to encounter issues, work to resolve them with their team and facilitate solutions that were real-world—as they would in the workplace—was viewed as an important experience: "This is a real question that is being posed. This is relevant. This is valid. This is something that we are going to work with after uni." Students commented that the process of working with others on the project felt as if they were working towards something that would have a real impact in the world: "It's like a shared goal, you want to reach the end, you want to produce something that's really good for the place that you're working at, or for what you're doing." Students felt they were delivering a better project outcome because of the passion they developed over the learning experience: "I think, because we've worked collaboratively with students from other disciplines, and towards the end we were so passionate about—our project—that we would probably deliver a better outcome."

Students suggested faculty could reflect on the project, the skills they have passed onto the students, and feel confident in how they had prepared them for the real-world, "They [staff] will come out of it knowing, okay I've prepared the students for the workforce…they've now got this knowledge…the experience of working in a team, working collaboratively." Further, students also suggested that staff members would reflect and build on the experience in future years by finding projects in areas where there are particular industry related issues.

Students felt the experience was a learning curve for staff who also had to learn from other people, including the students, rather than taking an individualistic, expert approach to educating students: "I think they'll also learn a lot from students … how to build a bit of a relationship that obviously goes both ways." Student also appreciated that the process encouraged staff to establish a relationship with industry: "It helps them establish a relationship with the industry a bit more so that they know what's going around in the industry."

*Enhancing industry*

Students perceived their contemporary knowledge was a valuable asset for industry partners because they were 'younger, newer, and fresher'. By addressing real-world problems, they felt they were able to demonstrate to industry that they had an understanding of the workplace context. Students recognized the benefits of having a team working on the project, and how more perspectives allowed for a better outcome: "Having everyone from different disciplines just means that lots of people are involved and are thinking about the deliverables and how to achieve the best outcome". Further, students recognized that the multiple perspectives adopted in project solutions meant that the ideas would be more recent, up-to-date, and creative. Finally, students also identified that project-based learning allows for issues to be resolved that benefit industry: "The reason why we're working on these trends, that we're doing these trends, is for a more beneficial future of work. We are the future".

## DISCUSSION

The aim of this research was to explore the impact of interdisciplinary project-based WIL for the stakeholder groups who participated in the four university pilots: students, faculty and industry staff. The major themes for faculty and industry partners aligned, suggesting similar outcomes from the experience. These outcomes are discussed in relation to engagement with real-world scenarios, change

in faculty's educational practice, project specificity and complexity, an integrated curriculum, and university-industry collaboration. Working with real-world problems generated by industry enhanced students' motivation to learn, which in turn led to a high level of autonomy and engagement during project-based learning. Students' highlighted the link between this engagement and the sense of empowerment they experienced working on something 'real' that had the potential to impact on the industry partner. The value of this authenticity in learning was illuminated by Esteban-Guitart (2014) as "effective learning involves meaningful activities and practices enriched by social, instrumental, semiotic, anatomical and individual mediations" (p. 297). Immersion in authentic problem solving in collaboration with industry, has been shown to prepare students for the professional setting (Piggott & Winchester-Setto, 2020). Furthermore, the opportunity to gain a deep understanding of concepts that potentially solve society's problems is central to project-based learning (Moalosi et al., 2012).

Students adopted a self-directed approach to learning and determined their own direction to address personal gaps in knowledge and skills. This personalized approach to student learning is a central element of project-based learning (Thomas, 2000). When compared to traditional teaching methods, project-based learning enhances students' self-efficacy (Bilgin et al., 2015) and professional identity formation (Tsybulsky & Muchnik-Rozanov, 2019). Others have noted the positive impact of project-based learning on students' self-esteem and self-actualization (Liu, 2016).

To ensure student autonomy and encourage them to take ownership of their learning requires a change from a traditional 'sage on the stage' pedagogy to a student-centered, 'guide on the side' approach. Faculty acknowledged the need for this transformation to their educational practice. This finding was not surprising given studies have shown that while faculty possess qualities from a range of different teaching styles (Grasha, 1994), most have a tendency towards the expert approach rather than the facilitator and delegator approach needed for this educational pedagogy. Professional development is required for faculty to embrace these active learning methods and to encourage the collaboration amongst staff needed for interdisciplinary learning (Lasauskiene & Rauduvaite, 2015).

Two key features linked to the success of project-based learning in our study where the specificity and the complexity of the project. Faculty found that the problem or challenge has to be clearly delineated to establish the scope, plan and outcomes of the project (including the final product). This specificity was linked to determining the roles and responsibilities of each of the stakeholder groups—students, faculty and industry. However, this finding should be interpreted with some caution as research into project-based learning indicate that it is best to use a 'driving question' or ill-defined problem to encourage students to engage, and struggle, with the issue to be solved (Thomas, 2000).

Perhaps one way to manage this need for specificity is to ensure complexity, the second important feature of the project in our study. Complex problems often require interdisciplinary solutions (Ramaley, 2014). By providing a complex problem to solve, students were required to engage their critical and creative thinking skills, and find a way to share their discipline knowledge with the team. That is, students needed to learn how to collaborate across their different discipline perspectives, to view the problem from broader, and potentially disparate, viewpoints and integrate this new knowledge to produce a coherent project outcome for the industry partner. Tasks such as this that incorporate interdisciplinary collaboration, complex problem solving, and creative thinking provide students with exposure to the authentic world of work (Lim et al., 2018). A recent review of project-based learning in undergraduate science programs found that projects with a high level of interdisciplinarity lead to greater gains in communication, teamwork and employability skills (Hart,

2019). More recently, Hayes and Cejnar (2020) found working with others was the highlight of students' interdisciplinary project-based learning experience.

Interdisciplinary project-based WIL aligns with an integrated curriculum, which blends theoretical understandings with practical application of knowledge and skills. This knowledge and skills transcend discipline boundaries and fosters the development of the individual across cognitive, social and affective learning domains (Barnett, 2012; Lim et al., 2018). Staff and students perceived this model of WIL as a transformative, critical pedagogy that prompted creative and critical thinking beyond the confines of specific disciplines (Ferns et al., 2021), thereby extending one's knowledge and skills to a broader context. Students' construction of new knowledge through in-depth inquiry during project-based learning relies on student choice, autonomy and authority (Condliffe et al., 2017). Others, including Zegwaard and Rowe (2019), advocate for similar integrated and holistic approaches to improve the outcomes of university education.

While interdisciplinary project-based WIL encouraged networking and relationships between faculty and industry, these new relationships are not without challenges. Dorado and Giles (2004) reflect on this challenge in their work on identifying paths of engagement, trust and collaboration between academics and industry partners "who belong to different worlds" (p. 25), and often have different goals. Bereiter and Scardamalia (2014) describe this challenge in relation to a difference in focus; academia focuses on knowledge building while industry focuses on knowledge creation. Whatever the cause, these partnership challenges must be addressed as this university-industry collaboration was critical to faculty's capacity to develop and implement interdisciplinary WIL curricula, and to the benefits industry partners perceived they gained working with the relevant university. A key role of faculty within this relationship was to facilitate discussions between industry and students to ensure a shared understanding of the scope of the project and the roles of the various stakeholders. As outlined earlier, this shared understanding was fundamental to a successful student learning experience. The collaboration broadened relationships between industry and faculty and, in some cases, renewed faculty's applied knowledge and focus. Other researchers have found that engagement with industry assists faculty in designing authentic assessments (Hodges, 2011). A key element of the relationship building from industry's perspective was that the project delivered a tangible outcome that met a real problem they faced. However, a perceived lack of flexibility on the part of some faculty—often in response to the rigid administrative practices of their institution—led to some pilot projects not being aligned with industry need. This result aligns with research into university-industry relationships in WIL that indicates trust, clear expectations and reciprocity are the most critical factors (Patrick et al., 2014). The need for universities to address this alignment issues is critical to the success of project-based learning as students posited that it was the sense of commitment to an industry partner that was a major factor in their high level of engagement, driven by their desire to add value to the organization and make a difference. Solving a problem in a collaborative team environment with their peers, faculty and industry inspired persistence and resilience as students were conscious of their obligation to others. Institutional leadership is essential for the ethos of interdisciplinary project-based WIL to be fully realized and stakeholders to be afforded the benefits inherent in this pedagogy. Leadership needs to rethink traditional policies, to enable innovative curriculum and assessment design, where students and staff from disparate disciplines collaborate to solve industry challenges. An institutional culture that promotes students as partners, prioritizes staff development, and values industry engagement is pivotal to successful implementation of interdisciplinary WIL (Patrick et al., 2014). When interpreting the results from this study it is important to note that the participants were self-selecting and from a limited range of disciplines, thus there is a potential for bias in their responses. This is particularly true for students with only 19 students interviewed out of the pool of 265 students who participated in the

pilot projects. The inclusion of participants from across four institutions who implemented quite different pilot projects goes some way to mitigate this limitation.

Finally, further research is needed to better understand how to prepare faculty for the change to a facilitator/delegator role, how to frame the problem (the driving question) to ensure students engage and struggle with complex ideas, and how technology can be utilized to expand interdisciplinary project-based learning within higher education.

## CONCLUSION

We continue to experience disrupted and changing workplaces that require future graduates with sophisticated employability skills. The COVID-19 pandemic has heightened the call for new models of WIL. This research indicates project-based interdisciplinary WIL provides an alternative to traditional student placements for building student's employability. The challenges and enablers identified provide guidance for both faculty and future research in this field. In summary, the recommendations for a sustainable and adaptable project-based interdisciplinary WIL model are:

- Employ a student-centered approach in project development aligned to clear, tangible outcomes in real-world contexts;
- Ensure the project is truly interdisciplinary with relevance for each discipline;
- Achieve agreement between faculty and industry partners on the scope of the project, role of participants and expected deliverables, ideally addressing an issue the industry partner is grappling with;
- Invest in relationships between faculty and stakeholders to optimize engagement and achieve best practice learning and teaching outcomes.

## ACKNOWLEDGEMENT

The authors acknowledge the Australian Technology Network for funding the research, the students who participated in the pilots and the staff who support them.

## REFERENCES

Barnett, R. (2012). Learning for an unknown future. *Higher Education Research and Development, 31*(1), 65-77. https://doi.org/10.1080/07294360.2012.642841

Bereiter, C., & Scardamalia, M. (2014). Knowledge building and knowledge creation: One concept, two hills to climb. In S. C. Tan, H. J. So, & J. Yeo (Eds.), *Knowledge creation in education* (pp. 35-52). Springer.

Brassler, M., & Dettmers, J. (2017). How to enhance interdisciplinary competence—Interdisciplinary problem-based learning versus interdisciplinary project-based learning. *Interdisciplinary Journal of Problem-Based Learning, 11*(2), Article 12. https://doi.org/10.7771/1541-5015.1686

Bilgin, I., Karakuyu, Y., & Ay, Y. (2015). The effects of project based learning on undergraduate students' achievement and self-efficacy beliefs towards science teaching. *Eurasia Journal of Mathematics, Science and Technology Education*, *11*(3), 469-477. https://doi.org/10.12973/eurasia.2014.1015a

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77-101. https://doi.org/10.1191/1478088706qp063oa

Brewer, M., Ferns, S., Lewis, S., Childers, J., & Russell, L. (2020). *Interdisciplinary project-based work-integrated learning: The Australian good practice guide*. Australian Technology Network. https://multisectorprojects.com/wp-content/uploads/2020/05/Good-Practice-Guide-2020.pdf

Condliffe, B., Quint, J., Visher, M. G., Bangser, M. R., Drohojowska, S., Saco, L., & Nelson, E. (2017). *Project-based learning: A literature review. Working paper* (ED 578933). ERIC. https://files.eric.ed.gov/fulltext/ED578933.pdf

Davies, A., Fidler, D., & Gorbis, M. (2011). *Future work skills 2020.* Institute for the Future for the University of Phoenix Research Institute. https://www.iftf.org/futureworkskills/

Dorado, S., & Giles, D., Jr. (2004). Service-learning partnerships: Paths of engagement. *Michigan Journal of Community Service Learning*, *11*(1), 25-37. http://hdl.handle.net/2027/spo.3239521.0011.103

Esteban-Guitart, M. (2015). L. S. Vygotsky and education by Moll, L. C. [Review of the book *L.S. Vygotsky and education*, by L. C. Moll]. *Journal of Language, Identity & Education, 14*(4), 295-297. https://doi.org/10.1080/15348458.2015.1070601

Ferns, S. J., Lewis, S., Russell, L., Childers, J., Brewer, M., & Alessandrini, J. (2021). Designing and implementing interdisciplinary project-based work-integrated learning. In S. Ferns, A. Rowe, & K. Zegwaard (Eds.), *Advances in research, theory and practice in work-integrated learning: Enhancing employability for a sustainable future* (pp. 167-178). Routledge.

Foundation for Young Australians. (2020). *The new work standard report*. https://www.fya.org.au/resource/new-work-order-research/

Grasha, A. F. (1994). A matter of style: The teacher as expert, formal authority, personal model, facilitator, and delegator. *College Teaching*, *42*(4), 142-149. https://doi.org/10.1080/87567555.1994.9926845

Hart, J. (2019). Interdisciplinary project-based learning as a means of developing employability skills in undergraduate science degree programs. *Journal of Teaching and Learning for Graduate Employability*, *10*(2), 50-66. https://doi.org/10.21153/jtlge2019vol10no2art827

Hayes, M., & Cejnar, L. (2020). Evaluating alternative work-integrated learning opportunities: Student perceptions of interdisciplinary industry-based projects. *Journal of University Teaching & Learning Practice*, *17*(4), Article 7. https://doi.org/10.14453/jutlp.v17i4.7

Hodges, D. (2011). Assessment in cooperative and work-integrated education. In R. K. Coll & K. E. Zegwaard (Eds.), *International handbook for cooperative and work-integrated education: International perspectives of theory, research and practice* (pp. 53–62). World Association for Cooperative Education.

Lasauskiene, J., & Rauduvaite, A. (2015). Project-based learning at university: Teaching experiences of lecturers. *Procedia-Social and Behavioral Sciences*, *197*, 788-792. https://doi.org/10.1016/j.sbspro.2015.07.182

Liu, X. (2016). Motivation management of project-based learning for business English adult learners. *International Journal of Higher Education*, *5*(3), 137-145. http://dx.doi.org/10.5430/ijhe.v5n3p137

Lim, L., Andrew, J., Lewis, S., & Gao, J. (2018). Interdisciplinary teamwork in an authentic project-based learning environment. In D. Wache & D. Houston (Eds.), *Research and development in higher education: [Re] valuing higher education* (Vol. 41, pp. 1-13). HERDSA. https://www.herdsa.org.au/publications/conference-proceedings/research-and-development-higher-education-re-valuing-higher

Lasen, M., Evans, S., Tsey, K., Campbell, C., & Kinchin, I. (2018). Quality of WIL assessment design in higher education: A systematic literature review. *Higher Education Research and Development*, *37*(4), 788-804. https://doi.org/10.1080/07294360.2018.1450359

Mills, A. J., Durepos, G., & Wiebe, E. (2010). *Encyclopedia of case study research.* Sage.

Moalosi, R., Oladiran, M. T., & Uziak, J. (2012). Students' perspective on the attainment of graduate attributes through a design project. *Global Journal of Engineering Education*, *14*(1), 40-46.

Oliver, B., & Jorre de St Jorre, T. (2018). Graduate attributes for 2020 and beyond: Recommendations for Australian higher education providers. *Higher Education Research & Development, 37*(4), 821-836. https://doi.org/10.1080/07294360.2018.1446415

Patrick, C-j., Fallon, W., Campbell, M., Devenish, I., Kay, J., Lawson, J., Russell, L., Tayebjee, F., & Cretchley, P. (2014). *Leading work integrated learning: A distributed leadership approach to enhance work integrated learning*. (Final report). Australian Government Office for Learning & Teaching. https://ltr.edu.au/resources/LE11_2084_Patrick_Report_2014.pdf

Piggott, L., & Winchester-Seeto, T. (2020). Projects of consequence: Interdisciplinary WIL projects designed to meet the needs of partners and students. *Journal of University Teaching and Learning Practice*, *17*(4), Article 9.

Ramaley, J. A. (2014). The changing role of higher education: Learning to deal with wicked problems. *Journal of Higher Education Outreach and Engagement*, 18(3), 7–22.

Rannikmäe, M., Holbrook, J., & Soobard, R. (2020). Social Constructivism—Jerome Bruner. In B. Akpan & T. J. Kennedy (Eds.),*Science Education in Theory and Practice* (pp. 259-275). Springer.

Repko, A. F., Szostak, R., & Buchberger, M. P. (2019). *Introduction to interdisciplinary studies*. Sage.

Smith, C., & Worsfold, K. (2014). WIL curriculum design and student learning: A structural model of their effects on student satisfaction. *Studies in Higher Education, 39*(6), 1070-1084. https://doi.org/10.1080/03075079.2013.777407

Thomas, J. W. (2000). *A review of research on project-based learning*. http://www.bobpearlman.org/BestPractices/PBL_Research.pdf

Tsybulsky, D., & Muchnik-Rozanov, Y. (2019). The development of student-teachers' professional identity while team-teaching science classes using a project-based learning approach: A multi-level analysis. *Teaching and Teacher Education*, *79*, 48-59. https://doi.org/10.1016/j.tate.2018.12.006

World Economic Forum. (2018). *The Future of Jobs Report*. https://www.weforum.org/reports/the-future-of-jobs-report-2018

Zegwaard, K., & Rowe, A. (2019). Research-informed curriculum and innovative WIL. *International Journal of Work-Integrated learning*, *20*(4), 323-334.

Zegwaard, K. E., Pretti, T. J., & Rowe, A. D. (2020). Responding to an international crisis: The adaptability of the practice of work-integrated learning. *International Journal of Work-Integrated Learning, 21*(4), 317–330.