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Framework for developing career readiness in Australian science degree undergraduates

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Abstract

As students transition from university education to employment, they require a range of skills and competencies to ensure future career readiness. Although work integrated learning (WIL) is recognised as an important opportunity to build graduate employability, its use has been limited within Australian undergraduate science degrees. Recent research has indicated that employers perceive science graduates lack some employability skills while academics can lack confidence to teach them. Science graduates also lack career awareness and may struggle to identify the transferability of those skills. We present the findings from our study which aimed to explore current practice, understand the nature of the challenges facing academics to implement WIL in the curriculum and identify possible solutions. Key roadblocks to the effective implementation of employability skill development included lack of opportunity/time to integrate skills into existing curricula, non-engagement of students, and uncertainty around assessment of employability skills. Potential methodologies to overcome these roadblocks were co-created with industry and recent graduates. These form the basis of our framework for the best practice introduction of career awareness and employability skills into undergraduate science degrees as well as the associated recommendations to: 1) Build scaffolded, integrated curriculum in which enabling skills are repeatedly developed; 2) Design WIL activities and assessment purposefully aligned to the packaged development of employability skills and career awareness; 3) Be explicit: explain when, how, why and what career readiness skills are being developed to students; and 4) Build capacity and capability to develop and deliver career readiness learning outcomes.

Keywords
employability skills, work-integrated learning, career pathways, career awareness, career readiness framework, undergraduate science

Introduction

Recent policy by the Australian Government has seen an emphasis on the development of job-ready graduates by the Higher Education sector (Australian Government, 2020; Dean et al., 2024). Universities are required to provide the foundational skills for specific roles in industry as well as opportunities for work-place experience(s). Greater communication with industry and subsequent alignment between industry requirements and graduate attributes is necessary (Oraison et al.,

2019), noting that bridging the divide between industry and Higher Education has implications for curriculum development (Orr et al., 2023). Indeed, the focus for universities appears to have recently shifted from whether graduates secure employment (that is, demonstrating they are work-ready) to equipping learners with lifelong skills to develop their employability (Dean et al., 2024).

Graduate employability is a complex concept (Jackson, 2016), that comprises a diverse range of skills, attributes, and other measures such as networking (Bridgstock, 2017), professional identity (Zegwaard et al., 2017) and active citizenship (Gamble et al., 2010). Expanding the framing of graduate employability from being work-ready to one of career readiness requires recognition by the Higher Education sector that career-management skills are necessary for maximum employability (Bridgstock, 2009). Graduate career readiness requires the development of reflective abilities and self-awareness (Jackson, 2018) to a greater extent than being job-ready or work-ready. Career-ready graduates can competently navigate ambiguity and uncertainty (Barnett, 2012) thereby adapting to the varied workforce situations and ever-changing career possibilities (Starr-Glass, 2019). Critical self-reflection skills enable the continual enhancement of employability skills benefiting graduates, the workforce, community and economy (Oliver, 2015a). Career readiness skills are also key determinants of good performance in the workplace potentially bringing growth to an employer's organisation (Peersia, 2024). As such, universities are pivotal to the development of graduates with the skills to enable industry success and growth. Furthermore, universities also play an important role in helping to engender self-efficacy in graduates. Self-efficacy refers to the ability of graduates to use skills, knowledge and attributes to achieve goals in various contexts (Rachmawati et al., 2024). Therefore, self-efficacy together with employability and career management skills will allow graduates to adapt to changing circumstances, shifting priorities and competing life-choices (Wallis et al 2021), thereby defining their career-readiness.

The embedding of work integrated learning (WIL) experiences into the tertiary curriculum, therefore, is important (Rowe & Zegwaard, 2017). WIL can include a wide range of tasks with varying levels of authenticity and proximity (Oliver et al., 2015b). Placement and project work usually provide the greatest opportunities to develop career readiness (Universities Australia, 2019) but there are workload and resourcing implications (Bilgin et al., 2024) and assessment can be challenging (Kaider et al., 2017). Therefore, there is an imperative to consider other WIL activities that will develop career readiness. Some of the attributes required for career readiness are captured in the national Threshold Learning Outcomes for Science, which have been adopted by several institutions in Australia (Schultz et al., 2023). However, recent research has shown that science academics lack confidence to teach some career readiness skills (Sarkar et al., 2020), especially resilience and conflict resolution (Hume et al., 2024). In addition, there are limited opportunities for interaction with industry in science-based degrees (Hume et al., 2024), while industry believes that graduates of Australian science degrees are least likely to have developed an ability to work independently, effectively communicate and effectively manage time (Hume et al., 2024). Recent science graduates also have a lack of career awareness and concerns about the transferability of the skills learnt at university (Hume et al., 2024).

Therefore, this research considered how to introduce career awareness and employability skills to science undergraduates by:

1. exploring current practice (the current status and perceptions of usefulness of WIL in employability skill development);
2. understanding the challenges to the implementation of WIL and teaching of career awareness for science academics; identifying possible solutions with academics, industry, students and recent graduates as well as characterising activities and strategies that develop employability skills in their experience; and;
3. exploring the ideal development of career awareness and employability skills in the curriculum with respect to how, what and when during a degree.

Outcomes from this research have also been used to develop the framework for developing career-aware professional science graduates, presented here. We acknowledge that there are many employability frameworks available (as reviewed by Eimer & Bohndick, 2023). Most conceptual models and frameworks of employability refer to career awareness, career management, generic skills, emotional intelligence and/or reflection including the graduate attribute model by Bridgstock (2009), the CareerEDGE model (Dacre Pool & Sewell, 2007); and Advance HE's framework for embedding employability (Tibby & Norton, 2020). Others such as the Career Management, Academic Skills, Personal Attributes (CAP) model for embedding employability provide more detail about learning activities that could be used within undergraduate STEM curriculum (Brent et al., 2017). WIL activities and whether they build critical capital can also be evaluated using the analytical framework by Winter 2023. Our career-readiness framework and associated recommendations provide a unique perspective by directly addressing the challenges faced by science academics in the implementation of WIL. Co-creation with academics, students and graduates has also enabled the inclusion of examples of activities, based on their experiences, that enhance career readiness by improving both employability skills and career awareness. While the emphasis has been on the career readiness of science graduates, we believe the framework and associated recommendations are also applicable to other disciplines.

Methodologies

This research, approved by the University of Adelaide's Human Research and Ethics Committee (H-2022-145), used a mixture of techniques: online and in-person surveys to collect data on current practice in WIL from students, recent graduates and academics; online and in-person workshops with academics, recent graduates and/or employers; in-person focus groups with students; and interviews with academics/employers/recent graduates.

Survey: Current status and perceptions of usefulness of WIL

A total of 30 academics, 149 students, and 35 graduates were recruited as per Hume et al., (2024) and surveyed as per Table 1. Demographics were also collected and reported in Hume et al., (2024).

Table 1: Survey questions on the current status and usefulness of WIL.

Stakeholder	Questions	Answer type
Academic	Do you use Work Integrated Learning in your own teaching?	Yes/No
	If yes, please indicate what approaches you use	Open response
	Are you responsible for overseeing or coordinating Work Integrated Learning in the Sciences curriculum at your institution?	Yes/No/Partially
	If you answered yes or partially, please indicate how you are involved in coordination of WIL in the Sciences curriculum	Open response
Student (Graduate)	Have you had (did you have) the opportunity to participate in activities that develop skills relevant to your readiness for a career during the course of your degree?	Yes/No/Not sure
	If yes, please indicate what activities you feel (felt) were most beneficial to you	Open response
	At what stage in your studies do you think that teaching of employability skills would be most useful?	During the first/second/final year/Throughout the entire degree/Not at all/Other (please specify).

Workshop: Challenges and solutions for implementation of WIL, strategies for development of employability skills and career awareness, and curriculum structure considerations

To explore academic perspectives, a state-based (South Australia in-person) workshop and a national online community of practice (CoP)-style workshop were held with a total of 34 academics from 11 institutions participating. Participants were asked to identify what the three greatest challenges are that academics face in teaching employability skills followed by discussion of possible solutions for any identified roadblocks to the implementation of WIL.

An online co-creation workshop with academics, industry, and recent graduates was then held to identify effective strategies for building career pathway awareness and developing employability skills in students. A total of 50 individuals participated with 11 being employers or recent graduates. Academic participants were from across 16 institutions. Participants were asked to consider how, what and when articulation of career pathways and the development of employability skills should be included in the curriculum.

Two further in-person workshops were held at the 2023 Australian Conference of Science and Mathematics Education (ACSME), with 25 participants from across 16 institutions) and at the University of Adelaide's Festival of Learning and Teaching 2023 (with 40 participants). Both considered how, what and when employability skills and WIL can be implemented during a degree. Participants at the ACSME workshop (our final workshop) were also asked to consider how specific employability skills might be included in the curriculum. The employability skills chosen were those previously identified by industry as requiring more development: time management; resilience, stress tolerance and flexibility; making confident decisions; and leadership (Hume et al., 2024).

Focus groups and interviews

Focus groups and interviews provided further data on key aspects discussed in workshops and also involved students. Student participants were invited via email by academics who had indicated an interest in the previously mentioned survey. Students were provided with a $30 gift card to acknowledge their time spent in participation. A total of nine students across two focus groups and three academics, three employers and two graduates participated in interviews after providing their informed consent. Focus groups and interviews were conducted by the lead researcher and research officers employed on the project. Discussion prompts focused on the perception of participants of career pathways, what and how employability skills could be developed including useful experiences. All discussions were recorded to allow preparation of a transcript which could be used for analysis.

Analysis of open responses

Data from open response questions in the survey, workshops, focus groups and interviews was subjected to thematic analysis. The survey data and transcripts were used by the research team to identify key categories/themes related to challenges and solutions to implementation of WIL, the development of student awareness of career pathways and the development of employability skills as appropriate. Responses (survey responses or sentences from transcripts) were then assigned to themed categories as individual lines to allow calculation of the percentage of comments categorised to a theme. A description for that theme/category was developed and example quotes identified.

Results and Discussion

1. Current status and perceptions of usefulness of WIL activities in developing employability

To determine the types of activities currently being used to develop employability skills and the perception of their usefulness, academics were asked to indicate via open response in the survey what they had delivered while students/recent graduates were asked via survey what they regarded as beneficial (Figure 1). Most academics that participated in the survey (63%) indicated that they had used WIL in their teaching. Of these, less than half were responsible for coordinating WIL in the Sciences curriculum at their institution (42%). These individuals were mostly subject or degree coordinators with some being directly responsible for liaising with industry to place students in a professional setting.

Internships/placements and the use of industry to provide guest lectures, participate in panels in the classroom or provide interviews to students were the most mentioned WIL activities by academics (22 and 24% of survey answers respectively) followed by industry-based projects (18%) and field trips to professional settings (16%) (Figure 1A). The use of authentic assessment was also mentioned (12%) with examples provided such as consultancy reports using industry problems and industry-relevant questions in examinations. Some academics were also involved with industry career and networking events, but many acknowledged that these events were often led by student clubs (and viewed as extracurricular). The development of specific job-related skills (such as preparation of a CV and development of interviewing techniques) was rarely mentioned (only 2% of comments) (Figure 1A).

For students, internships/placements (31%) and field trips to professional settings (23%) were considered useful more often, followed by industry networking and career nights (16%, Figure 1B). For graduates, the WIL activity considered useful more often was internships/placements (31%). Field trips to professional settings and industry/career nights were not mentioned as often by graduates (13% and 7%). Other WIL activities mentioned (but in 10% or less of survey comments) included industry-based projects, the use of industry to provide guest lectures and participate in panels in the classroom, and classes on specific job-related skills.

Although 12% of academic comments highlighted the use of authentic assessment as a WIL activity (Figure 1A), no student and only 2% of graduate comments indicated authentic assessment as a WIL activity (Figure 1B). These results confirm observations by others that students do not necessarily associate assessment with WIL, unless it involved performance-based evaluation and reflection of placements (Ajjawi et al., 2020) or WIL explicitly appears as proximal to the workplace (Kaider et al., 2017). High proportions of students have previously been reported to be unable to recall explicit mention of WIL for an assessment or to judge whether an assessment is regarded as WIL (Young et al., 2019). To address this, students should be inducted into the rationale for the authentic assessment and how it is linked to their future employment and life-long learning (Schultz et al., 2022). Practical classes and summer research scholarships (which usually entails a 6 to 8-week placement in an academic research laboratory for those institutions that participated) were not listed by academics as WIL, even though both were mentioned as useful WIL activities by graduates and students. Some graduates also mentioned extracurricular activities that improved their career readiness including having mentorship from industry and joining University committees as a student representative. This highlights the need for a clear and shared understanding of the various forms WIL can take.

The majority of student and graduate survey respondents also indicated that the teaching of employability skills was most useful if it occurred throughout the entire degree (83% for students and 91% for graduates) (data not shown). An example of this sentiment is captured by this open-ended response: '*These teachings should be maintained throughout the entire degree - this would give the students better opportunity to study something more relevant to their chosen career path as they grow and figure out what that may be'*. Indeed, we have previously reported that a large proportion of students change their career plans during their studies, especially after interacting with alumni and industry (Hume et al., 2024).

Figure 1A and Figure 1B: Types of WIL activities delivered by academics (A) and considered beneficial by students and graduates (B). Categories and proportions determined from thematic analysis of mentions of activities in the survey's open-ended responses.

2. Teaching career awareness and employability skills into the future: challenges and solutions

Solutions by academics to address perceived challenges for implementation of WIL in Sciences curriculum

When asked to identify the challenges to implementing WIL within undergraduate Sciences curriculum (in workshops), academic comments could be categorised into several themes: the current nature and structure of the curriculum; confidence (or capability) of academics to teach employability skills; student engagement and motivation to develop employability skills; access to resources (or capacity); and concerns with assessment and ensuring authenticity of both assessment and activity (Table 2). Flexible design of scaffolded curriculum, adequate resourcing and sustained external partner engagement have also been described as challenges by Jackson (2024). Issues with curriculum structure, capability and capacity of academics and student engagement were especially highlighted in our workshops. The focus of the discussion on capability reflects recent research that science academics lack confidence to teach some career readiness skills (Sarkar et al., 2020), especially resilience and conflict resolution (Hume et al., 2024). In addition, there was some discussion that employability skill development is often not explicitly described to students. For students to recognise a relationship between curriculum and learning outcomes, universities must communicate graduate capabilities strongly (Cavanagh et al., 2015). A focused curricular structure which foregrounds how students' employability is developed has been previously suggested as beneficial for Science students to reflect and make meaning of their undergraduate research experiences while also considering their personal growth (Carpenter et al., 2022).

The development and maintenance of industry relationships were also viewed as challenging. Most academics had established individual links to industry based on their research expertise; this hampers opportunities for *'large scale interaction with industry'*, which in some cases, resulted in multiple independent interactions between one industry individual and multiple academics or professional staff in the University.

When considering how to manage the roadblocks or challenges described in Table 2, the main types of solutions discussed usually related to the design of assessment and WIL activities, reorganisation of the structure of the degree to accommodate WIL, developing student engagement and building capacity (through provision of extra workload allocation and resources including those provided by industry and University career services) (Table 3).

Discussions about curriculum and assessment design focused on the use of flipped classrooms and the provision of reflective opportunities integrated during the degree using assessments such as e-portfolios and passports. The content focus of science curriculum presents a real challenge to academics with discussion at workshops suggesting that employability skills need to firstly be mapped across all units in degrees to enable prioritisation for the appropriate development of WIL activities and assessments. This process would also allow for the employability skills being developed to be made more explicit to students as well as to direct resources, including industry involvement, appropriately. Greater articulation of employability learning outcomes by academics could also improve student engagement as could the co-design of assessment tasks with students and involvement in extracurricular activities with student clubs (Table 3). Spending time explaining to students why they were undertaking activities and assessments related to employability skills was also discussed as being of benefit in motivating students to engage (that is, '*start with why'* as per Senek, 2011). When students make a direct link between coursework and their future employability skills, their engagement with assessment (and reflection) is captured (Miller and Konstantinou, 2022). Furthermore, academics felt that it was important that '*soft skills should be called enabling skills to improve engagement by students'* and to better reflect a shared goal of supporting students on their journeys of personal and professional self-actualisation (Healy, 2023).

Co-creation by academics with industry and graduates: Introducing students to potential careers and career pathways

When considering the introduction of students to careers and potential suitable career pathways, comments from workshop discussions can be categorised into three main themes: curriculum design (and activities therein), involvement of alumni and industry and motivation of students to engage in their future career pathway(s) (Table 4). The provision of mentorship and development of an understanding that careers are flexible was also discussed.

Many of the activities identified in the survey as being delivered by academics were considered beneficial by students and graduates (Figure 1). These were also provided by workshop participants as examples of activities to be integrated to a greater extent within future Sciences curriculum (Table 3). In-class activities such as interviews, videos and site visits where the '*career journey is shared*' were perceived as useful but would also require the involvement of alumni and industry. Extracurricular activities such as career nights and networking opportunities were also seen as useful, especially by industry, but the perceived lack of student engagement was of concern.

Improving an individual's locus of control (or sense of agency) has a major influence on career development motivation (Rachmawati et al., 2024). This lack of student engagement could therefore be addressed through co-creation of curriculum, supporting student clubs to host networking events, explicitly describing employability skills and careers to students, and providing advice and encouragement to students to undertake work experience and international study exchanges, volunteer and join professional societies. Constructive alignment and subsequent clear articulation of careers and specific employability skills aligned with activities and assignments in the degree was viewed as particularly important by workshop participants.

Other comments from academics also mentioned students' lack of understanding about the flexibility and variability of a career (Table 4). Therefore, more interactions with industry and alumni were seen as beneficial in the showcasing of different careers and to demonstrate the changing nature of careers in the Sciences. The student focus groups also indicated that they wanted more industry interaction facilitated by academics to be able to learn about '*different career trajectories*' (Table 5). However, there was acknowledgement that improving interactions with industry needs to be resourced by universities, regardless of discipline: '*interactions with industry, especially for internships, needs one face (just the University as a whole*)'. The importance of self-reflection and its integration across the degree (from first year) was also highlighted during workshops and focus groups. Self-reflection would enable students to understand and promote their employability skills to potential employers, while also working to develop those skills about which they felt less confident.

Explicit career conversations could occur within the core curriculum with the aid of career services at universities but need to be embedded within the discipline of interest for the student (Bennett et al., 2020). Career awareness can also be built at a whole of university level by using a career registration approach during each year's enrolment process (The Careers Group University of London, 2019). Students are asked questions which evaluate their career awareness enabling them to plan for future skill development and review/reflection. Data captured can also be used by academics to modify and custom-fit activities to their cohort(s) in the classroom (Cobb, 2019).

Table 2: Challenges to the implementation of WIL according to academics (in workshops)

Theme	Description	% of responses	Example quotes
Capability	Academics are lacking confidence/capability to teach or mentor students	28	• How does one teach these things? How assess? …e.g. teamwork (in shorter) timeframes • Many staff don't have these skills themselves - don't know how to teach them!!! • How do you teach resilience? • Need support services to help us teach employability skills • Shared examples from (other) academics can help.
Curriculum	Curriculum structure does not provide opportunity for WIL, inconsistency of integration, unsure of best timing within curriculum, difficult to integrate and ensure learning outcomes within a crowded curriculum	22	• The content focus does our students a disservice when we launch them into the big wide world • Is there time in the curriculum? • Skills are lost if they are confined to a single unit - students don't necessarily carry skills through • Crowded curriculum • Horizontal and vertical integration of employability skills - teaching in context - needs to be imbued with meaning.
Students	Lack of student engagement, understanding of WIL and background (motivation)	16	• Students who need to know these skills are the least likely to want to learn them • Resistance amongst students who find these skills difficult to demonstrate • Carrot/stick/intrinsic interest - what works to interest students? • Catering to broad abilities of students • Timing and relevance (often think only relevant if use in near-future).
Capacity	Resources (capacity)	12	• Hard to apply these to very large classes. Too many students to give individual advice/feedback • Assessment of transferable skills is very resource intensive.
Authenticity	Industry knowledge (authenticity) and knowledge of career opportunities	9	• Academics (often) don't have the industry awareness to give authentic emphasis • Need to overcome a mindset that science is research • University timetabling/rigidity/hierarchy mindset makes it difficult to integrate guest lecturers etc • Academics in science (often) don't know much about career opportunities outside of research.
Assessment	How to and volume of students, challenge of grading	9	• How to evaluate skills? Especially networking and resilience • Assessment and grading of employability skills - competency vs quantified grade? • VOLUME of students sometimes makes authentic assessment and engagement very difficult.
Other	Recognition, explicit language, art of reflection	5	• Common language across the program to help students recognise and reflect on skill development - needs agreement across academics • Most WIL skills are 'hidden' • Many academics do teach WIL skills, they just don’t really know it and therefore can’t articulate them to students.

Table 3: Solutions to challenges to the implementation of WIL, as identified by workshop participants.

Category	Description	% of responses	Example quotes
Activity and assessment design	Examples of teaching pedagogies, activities and different assessment types	38	• Career passport? Students to attend certain workshops/seminars/industry events/placements/modules to complete the passport. Embed one activity into each unit • Start an e-portfolio in year 1…students add the things they do in each unit to build skills • Enriching selected assessment tasks by making them more authentic; include real world content or format - does not require complete redesign • Put students in the position of a potential future career and solve a real-world problem = simple implementation • Highlight authentic signature assessments in each subject that focus on knowledge AND skills. Provide opportunities for critical self-reflection in these tasks.
Student engagement	Co-creation with students and highlighting the value of skills	28	• Ask every teacher to identify just one activity that contributes to these skills and make that explicit to students. It steals no time from content but shows students the why • Assessment in which students themselves must identify the real-world relevance of their learning • Most important is to help them see WHY they are learning XYZ, if we can't sell it, we shouldn't teach it.
Curriculum structure	Consideration of degree structure and timing of WIL	21	• Professional practice courses (3rd year) internship etc versus integrative learning (relevance/context) • Course at each year level for each major - embed within degree purposefully • Decisions on which skills to prioritise - room needs to be made in the curriculum (for the priorities)
Resources	Capacity-related demands and utilisation of industry	13	• Find other resources, e.g. writing and maths learning centre, career services • (Create) links to industry • Course/program based LMS sites that focus on skills, opportunities and resources across the years, supported by professional staff and academic staff • Utilise the student societies of the university and link them with industry.

Table 4. Thematic Analysis of the Workshop Discussions about the Development of Student Awareness of Career Pathways

Category	Description	% of responses	Example quotes
Curriculum design (and activities)	Examples of activities and their role in degree structure	39	• Get students to spend time on self-reflection and assessment tools to understand their temperament strengths and interests • Site visits can open student's eyes to what is out there • Give them opportunities to dip their toes in their water, units that are research intensive or perhaps align to a particular industry. The try before you buy model. • 'Be something other than a student' • Self-reflection needs to be something woven throughout a degree, not a modular add-on • Mock interviews with industry partners.
Alumni and industry	Involvement of graduates and industry (in curriculum activities and extracurricular events/roles)	25	• Seminars from people talking about their journey • Having alumni and recent grads interviewed on a video/deliver a panel or presentation so they can discuss how they made the first step and secured their first graduate role • We need to utilise industry by getting them to sponsor career nights/projects and get them to sponsor the student club or association of each degree and attend lectures • Ongoing mentorship with graduates/alumni who have gone on to different careers. • They need to see jobs - a day in the life of a recent graduate. Need to understand what businesses do and ways their degree is applied in industries.
Student engagement	Involvement of co-creation, student clubs and the provision of explicit outcomes and incentives for student participation in WIL	15	• Bringing in a career reference in each discipline unit to help them build a picture of what is possible • As a grad recruiter I hired students I MET as an industry partner on campus. I prioritised them from 1000 applications for only 10 jobs. We hire a person not a grade • Internships must be compulsory to change culture • I felt that the networking events were amazing but only the motivated usually attend and they are probably the ones that have it all sorted anyway???? • Lots of students do not turn up to employer on-campus events! How do we get them to realise how important it is to see employers and be visible • Student-organised networking.
Other	Advice about the flexible nature of careers and having a passion, encouragement to join professional societies and undertake extracurricular activities	21	• Offer non-confrontational and non-competitive ways of assisting them to become career-ready • Encouraging engagement in professional societies • University open days for high school students • Encourage students to volunteer to develop employability skills and industry networks, to explore what happens in the workplace • Students have a low-key fear that if their first job is not their dream career they will be trapped there • Help them see that another career is NOT a failure but instead shows discernment • Following your passion will probably get you a good career, if not, at least you will be very happy. That is better than being unhappy, doing something you do not like.

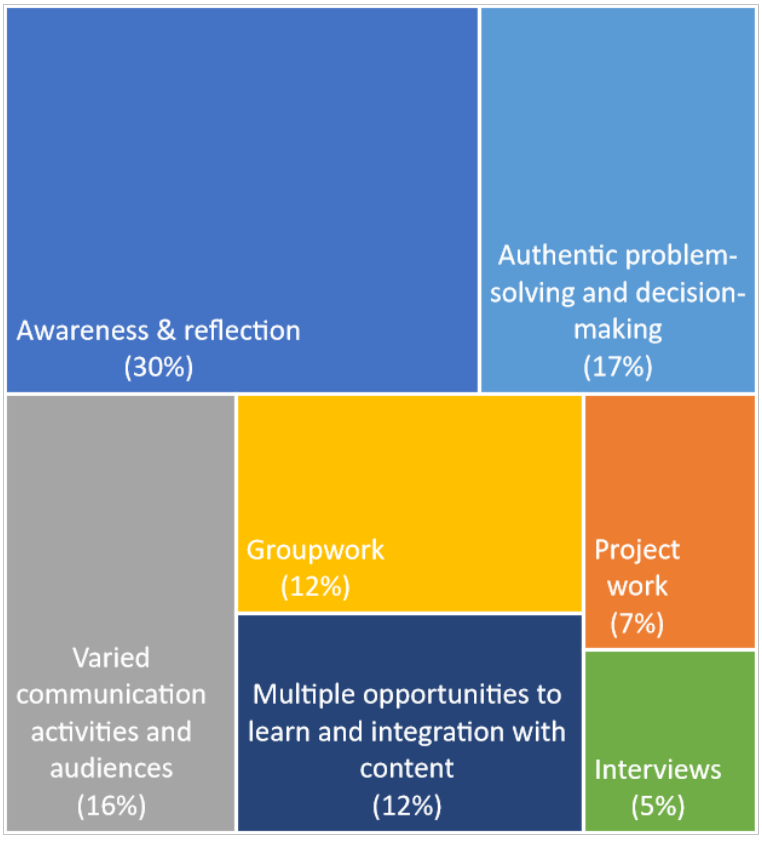
Co-creation by academics with industry and graduates: activities to develop employability skills in Science students

Comments from workshops about how employability skills should be developed could be categorised into the following themes in descending order (for number of responses): Awareness and reflection, authentic problem-solving and decision-making, varied communication activities and audiences, groupwork, multiple opportunities to learn and integration with content, project work, and interviews (Figure 2). Thematic analysis revealed that 30% of comments focused on awareness and reflection with an emphasis on ensuring academics were explicit in describing the learning of employability skills (for example, *'clarity of WHAT they are in fact learning and WHY (career relevance)'*).

Various tools and activities to help develop reflective abilities were also listed during workshops and interviews, including:

- Self-paced, regular reflection using directed questions such as those available at https://developingemployability.edu.au
- Using a skills diary/journal throughout the degree
- Developing an ePortfolio. ePortfolios, also known as integrative portfolios, should be carefully designed to include appropriate activities and authentic assessments that then contribute to the collection of evidence (and reflection) from across the degree (White, 2019)
- Pose interview-style questions during and after each unit/subject/course and require students to use the STAR method (where STAR = Situation, Task, Action, Result) (Tomasson Goodwin et al., 2019)
- The use of non-discipline-specific reflective techniques with activities of increasing complexity and depth as described by Harvey et al., (2020). Techniques include the development of mindfulness which contributes to the capacity for reflection while learning.

Figure 2: Themes discussed at workshops (including academics, industry and graduates) for activities that could be used to introduce employability skills



Given that students in the focus groups also perceived their own lack of awareness of employability skills and limited opportunities to reflect in a meaningful way (Table 5), the expansion of reflective activities within Science degrees should be prioritised. Our findings support the suggestion by Hill and colleagues (2019) that skills reflection should be fully scaffolded and assessed. Furthermore, enhanced self-reflection during problem-based learning and its contribution to decision-making was seen as important by academics. Self-reflection is critical to enable sound decision-making and strategic adjustments of responses to novel situations or problems (Fischer et al., 2012; Donovan et al., 2015). Reflection also allows revision of the process used by an individual to solve real world problems in science (Price et al., 2022). Some discussion also focused on demonstrating to students that decisions are '*often not black and white'* and that an evidence-based approach is appropriate in science. An industry participant indicated that students need to develop an '*awareness of how messy science actually is….and how to make judgements (confidently)'.* The use of authentic problem-solving activities and industry-relevant projects was seen as a mechanism for developing this understanding as well as multiple employability skills (for example, *'problem-based learning encourages development of conflict resolution, leadership and decision-making skills'*). Other than the development of positive feedback strategies (Hill et al., 2019), academics also need to work with students to '*establish ways of working and planning in terms of recognising where gaps are in their knowledge, what they need etc. so they can be confident within the known limits'.*

Comments by academics about the use of groupwork (12%) often overlapped with those on project work (7%) (Figure 2) and focused on using peer feedback and using codes of conduct/contracts for teamwork (such as those available at itpmetrics.com). Project and group work were seen as the main ways to develop multiple employability skills at once, especially time management skills; acknowledging other viewpoints; resilience; and making decisions '*by having students manage for hurdles/obstacles and be assessed accordingly'*. The student focus groups also considered group work as the main avenue for development of employability skills provided students were working with a mixture of individuals within the group (Table 5). Groupwork was also perceived by students to be a major course context in which to facilitate skill development in a study by Hill and colleagues (2019).

Another common theme regarding the inclusion of employability skills in the Sciences curriculum (12%, Figure 2) was that associated activities and assessment need to be integrated with those related to content (or knowledge). There also needs to be multiple opportunities to learn and be assessed for employability skills. Suggestions included: *'plan across the curriculum to ensure coverage and integration of skill building'* and *'Include examples throughout. How are industry and employers using XYZ?'.*

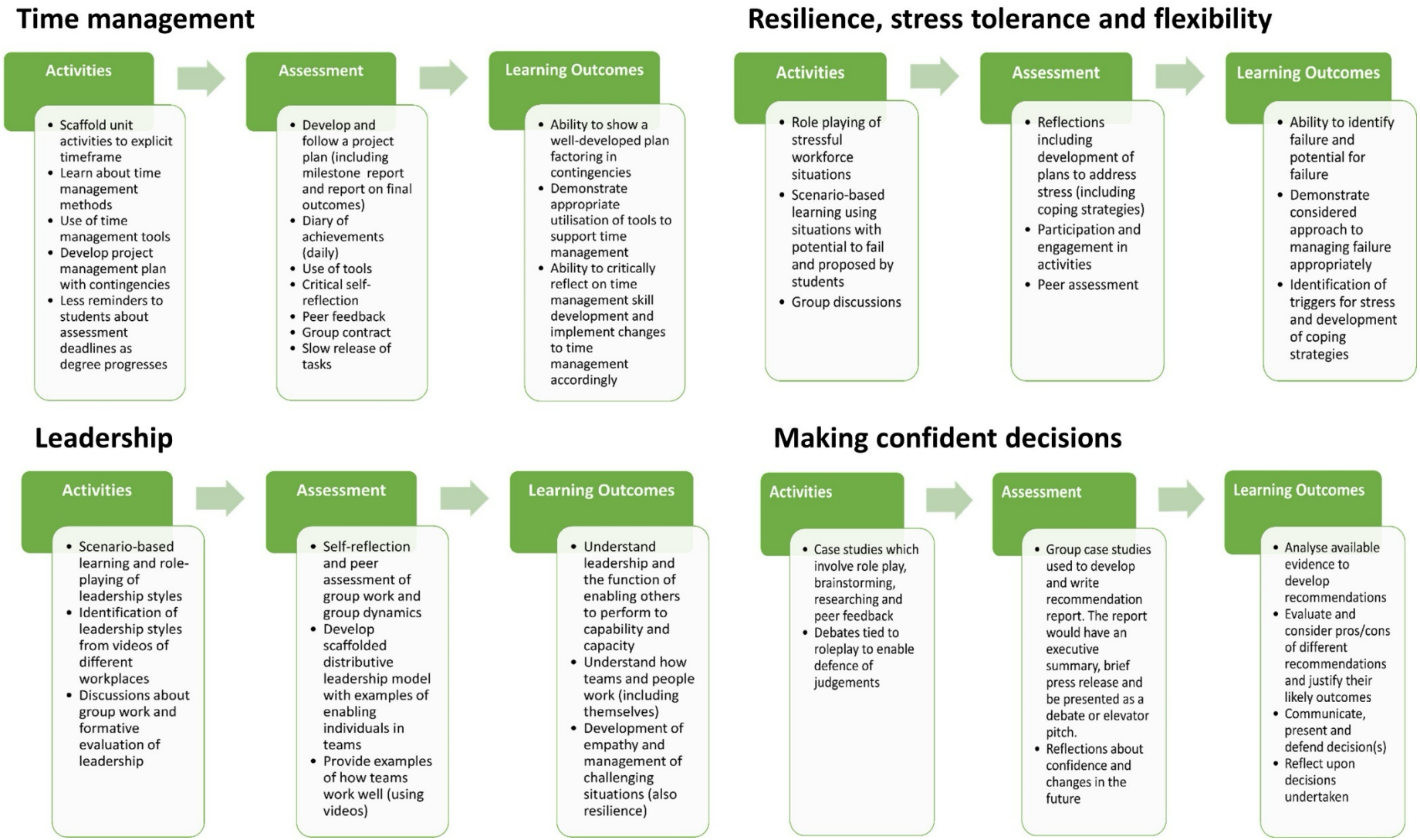
While comments about varied communication activities and audiences generally listed different activities and audiences, there were many comments seeking to build on interpersonal communication skills, such as '*spend time setting ground rules for appropriate professional communication'.*

Importantly, any learning related to employability requires scaffolding with students indicating the importance of this during the focus groups (Table 5). Students in the focus groups also suggested that employability skills could be developed by providing volunteering and networking opportunities for students as well as having compulsory industry placement for all Science students (Table 5). They also acknowledged that the extracurricular activities that they participate in can also develop their employability skills. Interestingly, academics also flagged concerns at the workshops about the disparate backgrounds of students and how they can cater to the diversity of experience: '*Do we really know who our students are? Other things they do that impact their career readiness?'* As such, academics indicated that self-paced modules may be of benefit because there are *'Different ecological niches for different groups of students – need to support each niche at different times'*.

Table 5. Themes from Student Focus Group Discussion Categorised as Related to their Development of Employability Skills

Theme	Description	Example quotes
Perception of attainment and learning	Usefulness and attainment of employability skills, articulation of those skills	• I am learning all those skills, but I think there's not enough of it. Like there's not enough framework. You might have the skills, but you probably don't even know what it is that you need to know? • I think with a lot of these skills that are very abstract skills, I think I'm not sure how useful they would be … with a lecture about this, I think that a lot of students would just go there, sit there for like an hour and then have learned nothing. So, I think (needs to be) learning by doing. • Well, I think it's been fairly easy to know the skills that it takes to be good at university. Not sure how well that prepares you for the real world.
Scaffolded Learning	Need support to learn employability skills	• I will use skills when I graduate but need help to learn so I can sort of, am being able to go on without the whole back up there • You need overall a quite protective environment which allows people to not make decisions or to have excuses for what they've done wrong. I think that's a skill you would only build once you are in the deep end. You would very soon realize you're in the deep end and you will start to improve actually much more faster [sic] than what you have come across in uni and I don't think it's wrong with uni to protect us … if outside, you're basically screwed if you did anything wrong.
Groupwork	Working in groups is beneficial for employability skill development	• I think some random (groups) is maybe more interesting just as if I was involved in a business. I did a project across different faculties, so I met a lot of people, and they all studied different things and I gained more of the soft skills than working with the people from the same degree. • I think it's better if we can randomize the group rather than keep working with the same people. It would be unpopular, but it would be what you face in, in a career … in the real world, you are not going to work with people you like most.
Assessment and reflection	Reflection needs to be assessed, scaffolded and meaningful	• It always feels so superficial. It's just always at the end. It's like a minimum tag on. Please reflect on the thing and it always follows the same sort of generic format of … 'I didn't achieve this. I feel bad about it. I'll fix it next time' and I never really do. • No real ability to honestly and critically reflect without it being the same thing that you can do without thinking. So, I think it needs to be graded, but it can't just boil down to that formula. It needs to be something honest and a bit more. Yeah, I would say truthful, but yeah, involved. • If it's not assessed, then you are just going to do it without paying any attention to it or anything.
Specific Ideas	Other ideas provided by the group relating to employability and career readiness	• The best thing that I think that uni does for employability is anything that encourages networking and meeting people, which they do and is invaluable. • LinkedIn profile creation, resume creation, that sort of thing. • Compulsory hours of industry placement. It forced me to go out and find jobs and opportunities for volunteering. • Reflections on each course and contributions to learning could be useful.

Figure 3: Alignment of activities and assessment to learning outcomes for selected employability skills



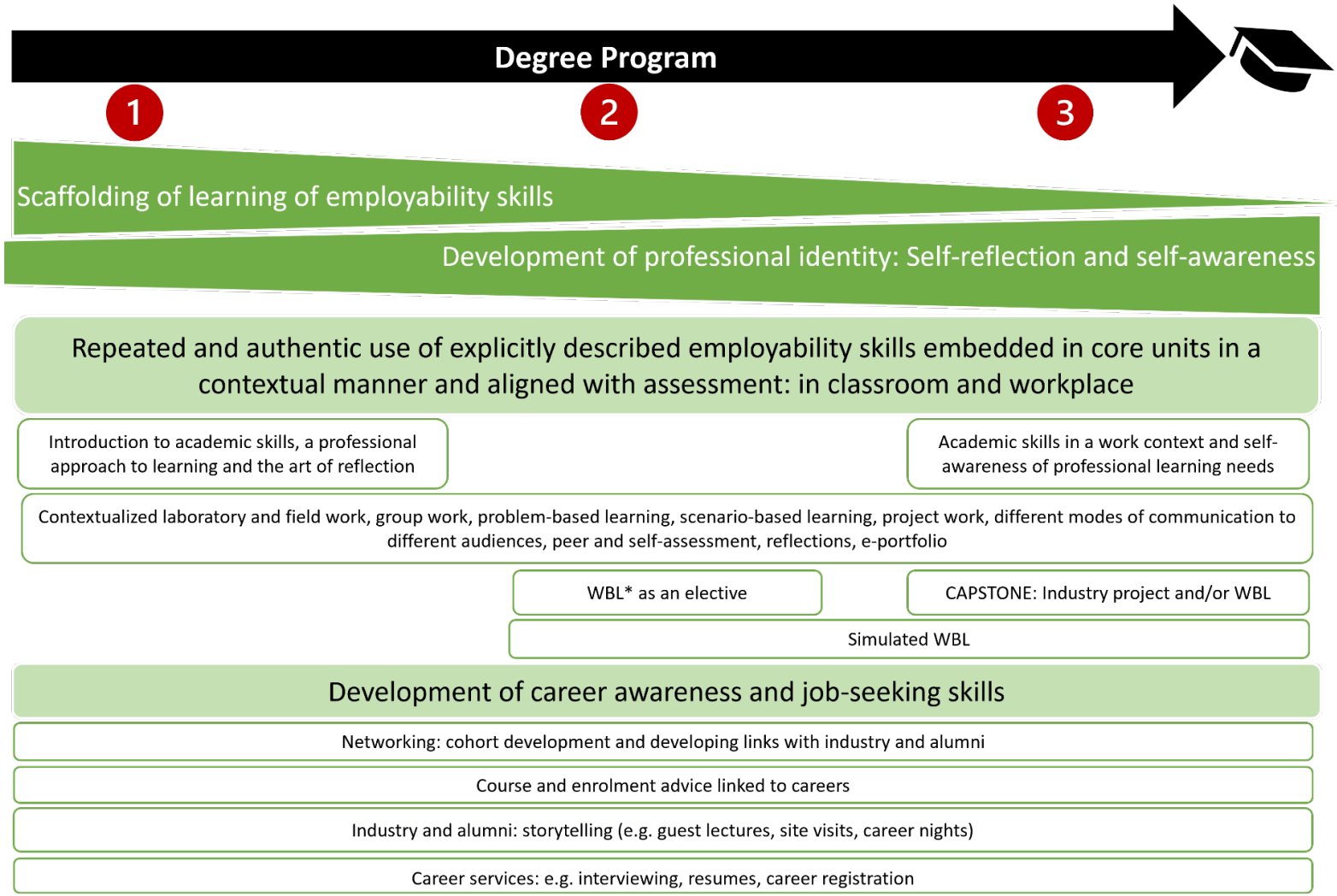
Participants in the final workshop were asked to align activities, assessment and learning outcomes for each of the following employability skills (Figure 3), chosen because industry had highlighted these as not attained by graduates (Hume et al., 2024): effective time management; resilience, stress tolerance and flexibility; leadership skills; and making confident decisions. The resultant information provides an overview that can be implemented by academics, especially where they are less confident in teaching a skill. The authenticity and proximity to workplace varies for the example activities (Oliver, 2015b; Kaider et al., 2017) and workshop participants commented that undertaking a process of alignment 'helps us to explain the relevance to students and why it matters'. Using this approach of constructive alignment could therefore address the previously mentioned concerns about making the development of employability skills more explicit. Ensuring that students are informed about why each activity (and assessment) matters also allows students to shift from an isolated inward-looking stance to that of a collaborative society (or workplace) member (McArthur 2023). Such an approach is likely important with STEM students appearing to have greater social utility motivations (that is, desire to work with, care for and help others) than students from other disciplines (Bennett et al., 2021).

3. Career awareness and employability skills: how, what and when during an undergraduate degree

Workshop participants (academics) considered the previously presented data before being asked how, what and when employability skills and WIL can be implemented during a degree. Figure 4 summarises the outcomes of those discussions and forms the basis for the key recommendations to improve career readiness of Science graduates as described in the framework (Figure 5). Employability skills should be '*Embedded and often (repeated)*', particularly within core units of the degree to ensure all graduates have opportunities to develop employability skills. Students are helped to better articulate transferable skills when learned in concert with course content (Moore & Thaller, 2023). Being explicit about what students are learning is also necessary. Furthermore, use of employability skills should be authentic to enable contextualisation while alignment with assessment is essential. Career awareness and job-seeking skills should also be developed and revisited across all years of a degree. As students progress through their degree, they will require less scaffolding and should be developing their professional identity (including self-reflection and self-awareness capabilities) (Figure 4).

At the start of their degree, students should be introduced to the art of reflection and academic skills necessary to succeed at university including '*learning a professional approach to one's learning'.* Regardless of year, curriculum should include a whole range of opportunities, including workplace-based learning (WBL), which is most effective in the latter half of the degree. Workshop participants voiced concerns about only allowing WBL for those students that have already shown engagement and development of employability skills. Academics need to consider *'not sending students who are not ready'* to *'avoid reputational risk to the University and potential issues for industry partners'.* WBL could be simulated in years 2 and 3 for those requiring further development. Where appropriate, WBL could also be used as an elective in year 2. However, workshop participants felt that all students should undertake a capstone that allows them to participate in an industry project and/or WBL ('*tailored to each individual*'). WBL will help to provide organisational acumen, important for work-readiness (Caballero et al., 2011; Orr et al., 2023). The timing of WIL activities, the required scaffolding and the types of activities discussed by academics are similar to those suggested by Kaider et al. (2017).

Figure 4: Introduction of career awareness and employability skills during an undergraduate degree: How, what and when. The numbers refer to the year level of the degree. * where Workplace-Based Learning (WBL) includes internships/placements/work experience



To develop career awareness and job-seeking skills, workshop participants agreed that there needs to be multiple opportunities for networking across the degree. This not only provides the development of links with industry but can also enable cohort development and greater communication about career pathways amongst students, allowing them to build upon and share experiences. Industry and alumni can be used for various storytelling opportunities within both curricular and extracurricular activities. Course and enrolment advice could also provide specific career examples while University-wide expertise available to academics such as career services could be utilised for certain activities, for example, interviewing and the development of resumés.

Recent reports suggest that employers perceive a lack of some career readiness and workplace skills in Australian graduates (Bennett et al., 2021) and Science graduates (Hume et al., 2024; Australian Industry Group, 2016; Prinsley & Baranyai, 2015). Therefore, it is imperative that institutions teaching undergraduate Science (and related degrees) improve curricula and address the gaps therein. Significant and sustained financial investment by institutions, industry and government is required to support quality, inclusive WIL (Jackson, 2024). Therefore, a strategic approach that shapes the vision of WIL in each institution and provides leadership to enable the creation and sustenance of WIL relationships is needed. The framework (Figure 5) aims to aid in the development of that approach.

Conclusions and the framework

Engagement of academics, students and industry partners in learning and teaching is necessary to develop shared understanding about WIL and build sustainable WIL practice (Patrick et al., 2014). The research presented herein aligns very closely with the WIL Guide for Science (https://www.acds.edu.au/teaching-learning/wil-guide-for-science/) and the recommendations previously made by the Successful WIL in Science project (Johnson et al., 2019). We also observed a need to provide more WIL opportunities and make them more visible; expand WIL opportunities to include simulated workplace experiences and a full range of activities to build career readiness; and provide credit to maximise student engagement. Many of the examples collected during this research aligned closely with the competence-based dimensions of employability suggested by Römgens and colleagues (2019) including social skills such as networking; ability to continue learning and pro-actively adapt to changing situations; and metacognitive skills to reflect upon goals, values, ambitions and career identity. Furthermore, many of the learning activities identified by academics and students in this study were also suggested as being useful by Brent et al. (2017) in their Career Management, Academic Skills, Personal Attributes (CAP) framework for embedding employability within undergraduate STEM curriculum.

To address the identified challenges, and using the outcomes from this research, we have developed a framework (Figure 5) that will guide academics and academic leaders to meet the following recommendations to develop career-aware professional science graduates:

1. Build scaffolded, integrated curriculum in which enabling skills are repeatedly developed
2. Design WIL activities (and assessment) purposefully aligned to the packaged development of employability skills and career awareness
3. Explain when, how, why and what career readiness skills are being developed to students
4. Build and develop capacity and capability to develop and deliver career readiness learning outcomes.

1. Build and develop curriculum architecture

Before designing activities and assessments that further develop enabling skills (that is, skills for university learning, employability and life-long learning), the delivery and assessment of these skills within Science (and related) degrees must be mapped within the curriculum (see 1 on Figure 5).

Given the national requirement to specify degree design and demonstrate the coherent achievement of learning outcomes (Australian Government, 2021), institutions regularly map unit learning outcomes and the associated assessment to expected degree learning outcomes. These mapping exercises can then be used to determine updates for the curriculum to ensure threshold learning outcomes are met (Acuna et al., 2016) as well as to evidence levels of achievement for graduate employability (Oliver, 2015a). This curriculum review should occur on a regular basis and consider the student entering the program (Hume et al., 2024) as well as other stakeholders such as industry partners (Webber et al., 2024). Auditing and mapping of employability provisions is also necessary in Advance HE's Framework for Embedding Employability so that any actions for curriculum change can be prioritised (Tibby & Norton, 2020). Mapping of employability skill and career awareness development will allow the identification of opportunities to embed WIL so that they meet the following conditions (see 2, Figure 5): is scaffolded as required (dependent upon year level), integrated with relevant discipline content in an authentic manner and learning repeated enough times that development is assured. Curriculum redesign with employability at the centre of the design should be considered (Rowe & Zegwaard, 2017). A wide range of activity and assessment types should be used and a compulsory WBL or industry-based project should occur as a part of a capstone unit in the final year of the undergraduate Science curriculum (Figure 4). When considering the inclusion of employability skills within the curriculum, emphasis should be given to those skills that graduates are less likely to have attained, especially as perceived by employers, or that academics are not confident to teach (Hume et al., 2024).

2. Design and build activities (and assessment)

Although curriculum mapping might consider each individually defined employability skill, a combination is more likely to be used within the workplace at any one time (Römgens et al., 2019). Therefore, academics should strategically design contextualised activities that deliver a package of employability skills and simplify the learning outcomes for students accordingly. The simplified domains (or packages) of skills in the framework (3, Figure 5) derived from the discussions and examples during this research are:

- Learning skills ('*learning to learn'*). Essential enabling skills for success at university and for life-long learning. Includes effective communication, effective time management and builds metacognition.
- Career awareness. Developing an understanding of different jobs and the requirements to succeed in those jobs and to build a career. Enabling self-reflection. Learning how all individual employability skills are applied in the workplace.
- Networking. Developing confidence in interpersonal communication and effective communication practices including the acknowledgement of viewpoints of others and appropriate response(s). Building opportunities to collaborate and to create, innovate and initiate in response to learnings from networking. Develop flexible thinking to make confident decisions in response to others' comments.
- Professionalism. Understanding corporate and workplace culture to meet expectations of professional behaviour in the workplace (and at university). Developing skills in ethical practice, effective time management, teamwork, making confident decisions in a professional manner, and working independently (to deliver upon a task when required by the workplace). Developing self-reflection abilities to ensure fit to the workplace as well as an ability to tolerate stress and be flexible.
- Intercultural literacy. Learning how to acknowledge viewpoints of others and respond appropriately while reflecting on one's own belief and traditions (including self-regulation). Enables effective communication, management of conflicts and working effectively within a team.
- Groupwork. Developing an ability to work within a team effectively (that is, working as a team to achieve a workplace objective). This may require conflict resolution, leadership,

effective communication, effective time management, and acknowledging the viewpoints of others and responding appropriately. Flexibility is often required to accommodate other team members and changing work conditions within the group. Working as a team can also build creativity, innovation and initiative as all individuals' competencies are used in collaborative activities (Hammar Chiriac, 2014).

- Project management. Development of organisational skills to manage a project to agreed completion with the available resources and any constraints accounted for. Enables the development of effective time management practices, leadership techniques, and implementation of ethical practice. Often requires flexibility and innovation to adapt to rapidly changing circumstances and effective communication to manage all contributors to the project. Develops ability to judge circumstances affecting delivery a project, create solutions and make confident decisions. If long term, can help to develop resilience and stress tolerance.

Types of learning which will capture these domains include groupwork, industry-linked projects, problem-based learning (PBL) and WBL (4, Figure 5). The design of activities and assessment should occur concurrently and with constructive alignment to the desired learning outcomes for that skill or domain (example alignments for individual skills were shown in Figure 3). Based on the results from this research, activities (and associated assessments) clearly also need to be designed in the context of the workplace (5, Figure 5) and examples integrated with content to provide motivation for the learning (for example, '*I'm working for x and do y*'). Provision of realistic examples through collaborations with industry (and alumni) will therefore be important to achieve this integration successfully (and ensure authenticity). Indeed, assessment needs to be responsive to individual student circumstances and their unique experiences (Winchester-Seeto & Rowe, 2017). Furthermore, assessment (formative and summative) must include multiple opportunities for reflection before, during and after WIL, especially for WBL and industry-based project work (6, Figure 5). Programmatic assessment, although challenging to implement, may best demonstrate attainment of career readiness (Charlton & Newsham-West, 2024) via the tethering of multiple work-related authentic assessments to WIL and career awareness learning (for example, Young et al., 2024).

To improve career awareness, there needs to be increased opportunities for students to discuss careers and the possibilities (or different directions) in undergraduate science curriculum (7, Figure 5). As per Figure 4, we recommend incorporating the following activities on a more regular basis:

- Linking all course and enrolment advice to example careers
- Delivering and assessing job-seeking activities such as interviews and resumes in the curriculum (including via career services)
- Embedding career 'storytelling' by industry and alumni in the curriculum (especially guest lectures and site visits)
- Extracurricular activities that enable interactions with industry and alumni (such as career nights and other networking events) could also be co-created with students, for example, via collaboration with student clubs.

3. Be explicit about career readiness skills

Concerns about the lack of explicit description and alignment of employability skills with activities and assessment in the undergraduate Science curriculum were common during this research. Being more explicit about employability skills-related outcomes (8, Figure 5) was seen as necessary to improve student engagement and literacy. As already discussed, the mapping of career readiness skills will enable the greater articulation of when, how, why and what skills are being developed by students for their future careers. Using reflective activities more broadly has been shown to develop multiple employability literacies even within early-year courses in science (Carpenter et al., 2024). Designing 'assessment for employability' will also encourage learners to identify and self-assess their

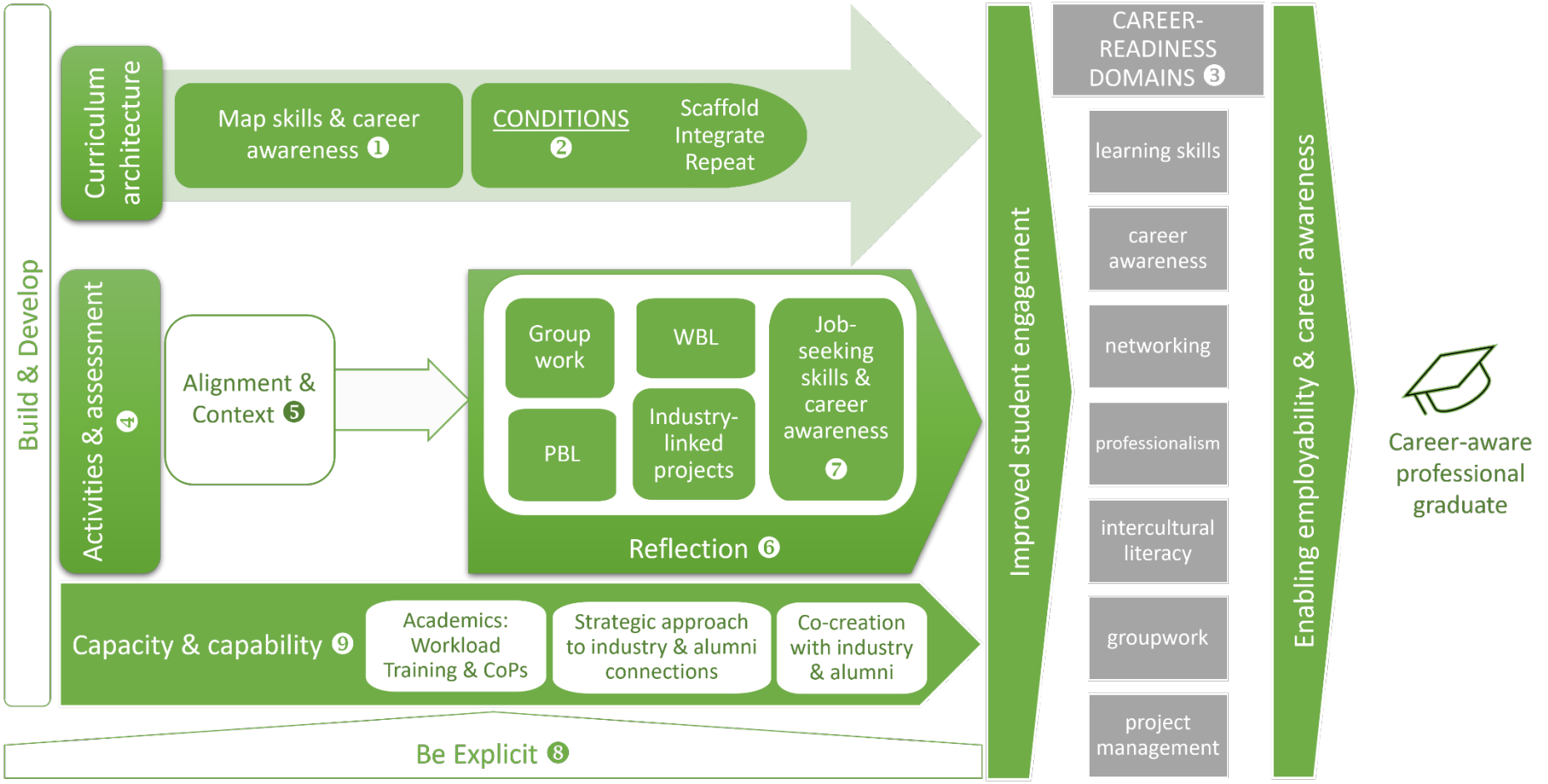
capabilities (Jorre de St Jorre & Oliver, 2017). Therefore, Science graduates should also be able to recognise the transferability of their skills and any gaps in their own capabilities to enable them to address professional development requirements now and into the future (life-long learning). Indeed, the inclusion of a skills portfolio (White, 2019) where the purpose and value has been made clear would also enhance student engagement and allow reflective abilities to be developed (Jorre de St Jorre & Oliver, 2018). Embedded portfolio assessments across units within a degree and across structured university and unstructured workplace learning will allow students to continuously reflect and learn to transfer skills and knowledge between contexts (Brent et al., 2025).

4. Build academic and institutional capacity and capability

The main challenge for the effective implementation of WIL into undergraduate Science curriculum appears to be the lack of resources to improve industry connections and support curriculum development. Therefore, to achieve improved career readiness learning outcomes for undergraduate Science graduates, institutions must build capacity and capability (9, Figure 5). This recommendation underpins the successful implementation of the other aspects within the framework. More specifically, the following are recommended:

- **Modify academic workload allocations to prioritise embedding career readiness in the undergraduate Science curriculum.** Provide academics with more time and resources to develop industry and alumni connections as well as to map and design career readiness activities and assessments that are integrated with science content. Time has been recognised as necessary to determine the most effective approaches to WIL assessment (Winchester-Seeto & Rowe, 2017) as well as to redefine academic work to include on-the-job professional development for embedding WIL (Price & Lizier, 2024).
- **Build confidence and capability of academics to teach and explicitly describe employability skills.** Priority should be given to training of academics for those employability skills (and domains) that academics are less confident to teach (such as resilience; Hume et al., 2024). Communities of Practice (CoPs) can provide collaborative opportunities for 'thinking together' to mutually guide each other through an understanding of similar problems via the indirect sharing of tacit knowledge (Pryko et al., 2017).
- **Develop a strategic and shared approach to developing industry and alumni connections.** Individual academics should continue to create, maintain, and improve their own relationships with individuals in industry and alumni. However, a whole of institution approach will be more time-efficient, cost-effective and enable resourcing of more partnerships (and on a larger scale). In addition, having 'one face' allows more effective management of partner expectations if there are clear processes and systems in place (such as the stakeholder contributions framework at https://www.acds.edu.au/teaching-learning/wil-guide-for-science/). Promotion of opportunities to employers and greater articulation of learning outcomes for students is also necessary. Maintenance of employer and alumni databases centrally will also help academics when seeking external input to curriculum development and as WBL hosts.
- **Engage with industry, alumni, and institutional support services to co-create WIL and promote career awareness.** Involvement of industry can lend greater authenticity with storytelling by industry and alumni directly building capacity to develop career awareness. Capacity can also be built by utilising the expertise of staff within institutional career services (or similar), especially for activities and assessments related to job-readiness and career awareness. Co-creation with industry will also be important to ensure shared understanding of career readiness and graduate outcomes. For example, Hume et al., 2024 identified that even though most academics were extremely or very confident to teach effective communication skills, industry ranked achievement as low for graduates. Therefore, a discussion seeking industry perspective should be a priority.

Figure 5: Developing Career-Aware Professional Science Graduates. A framework capturing the findings and subsequent recommendations from this research to develop career readiness in science graduates. Numbers are referred to in the main text



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Conflict of interest

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Declaration on the use of AI

No use of Artificial Intelligence was made at any point in this submission.

CReDIT authorship contribution statement

AA conceptualised the study. All authors had input into the design of data collection and delivery of workshops. RH, TW, JP and AA collected and analysed data. AA and RH drafted the manuscript. All authors critically reviewed the manuscript and approved the final version.

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