Are we Developing Career-Readiness Skills in Australian Science Graduates?

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Keywords: employability skills, work-integrated learning, career pathway

Abstract

To ensure future career readiness, students must develop a range of skills and capacities including technical expertise, problem-solving abilities, effective communication, social and professional network building, interpersonal and cultural awareness, resilience, and adaptability. The fluidity of careers also requires a greater emphasis on the development of metacognitive and reflective abilities so that graduates will have the capability, capacity, and confidence to use their personal resources appropriately and flexibly, regardless of environment. The research presented aimed to understand more about the employability skills viewed as important by four stakeholder groups - academics, students, graduates and industry - whilst also gauging perceived levels of attainment and confidence in those skills. The confidence and capability of academics to prepare Science students to be career ready was explored by conducting surveys and community-of-practice style workshops. The perspectives of industry employers, students, and graduates was sought via surveys, workshop and/or focus groups. In general, the ranking of the importance of employability skills was similar regardless of stakeholder group. Effective communication, effective management of time and working within a team were commonly deemed most important, while all groups ranked leadership skills and conflict resolution as of lesser importance. However, industry felt that ability to work independently, effectively communicate and time management skills were least likely to have been attained by Science graduates. This contrasted with most graduates indicating they were more confident in having attained these skills, and academics indicating they were more confident to teach these skills. A lack of career awareness was also identified, with many students changing their perspectives on career pathways after interactions with industry.

Introduction

Career readiness is generally understood as the proverbial bridge that helps students transition in the short term from university education to graduates prepared for the workforce (Dodd, Hanson & Hooley 2022). This transition necessitates students identifying and attaining an arsenal of skills in the domains of personal and professional capacities that are desirable in the eyes of employers (Jackson 2018). These may include technical skills and complex problem solving (Schonell & Macklin 2019; Tomlinson 2017), communication and language skills (Paull, Lloyd, Male & Clerke 2019), networking and mobilising social connections (Roberts & Li 2016), interpersonal and cultural awareness (Jackson 2018), resilience, risk tolerance and adaptability (Tomlinson 2017), as well as the development of rounded self-identity (Jackson

2017). A number of these attributes are captured within the threshold learning outcomes for Science graduates (Jones, Yates & Kelder 2011; Australian Council of Deans of Science 2023). However, given that careers are continuously changing (Starr-Glass 2019), graduates also need to have learned how to critically perceive, engage, and reflect on their own identity and self-efficacy (Jackson 2018).

A recent study by Sarkar, Overton, Thompson and Rayner (2020), with participants from one Australian and one United Kingdom University, identified a lack of generic skill development in individual units within undergraduate Science curricula and a lack of academic confidence to deliver/teach those skills. The embedding of work integrated learning (WIL) into undergraduate Science curricula is viewed as an important mechanism for the development of employable graduates (Johnson et al 2019). However, there appears to be an often-common perception that WIL must happen primarily within a workplace (via internships, placements etc) (Australian Collaborative Education Network 2014). To develop employability skills, the collective WIL experiences for an undergraduate degree should have a spread of assessed tasks with varying degrees of authenticity and contextual proximity (Oliver 2015). Indeed, a study of the perspectives of Science graduates from Monash University, and of employers, on employability identified that, while placements were important, other WIL opportunities such as making career pathways clearer to students, deliberate design of relevant inquiry-oriented approaches and building networks with industry, were changes required by the University sector (Sarkar, Overton, Thompson and Rayner 2016).

Benchmarking of Australian institutions shows that placements often do not appear to be compulsory in undergraduate Science curricula (data not shown). Furthermore, anecdotal evidence suggests that the further study pathway (i.e. Honours, Masters and PhD) is often promoted to a greater extent than industry-related careers to Science undergraduates by individual academics. However, in 2021, only 41.1% of domestic and 45.1% of international Science and Mathematics undergraduates went on to further study (Quality Indicators for Learning and Teaching 2021).

There appears, therefore, to be a real need for individual academics and teaching teams to engage further with industry and develop career-readiness in Science undergraduates by enhancing WIL opportunities and career awareness within classroom activities and assessment. In order to effectively develop curriculum which meets the goal of producing career-ready graduates, a clear alignment between industry and institutions with regards to the required graduate attributes is pivotal (Oraison, Konjarski & Howe 2019). Confidence in the ability of undergraduate programs to prepare students for their professional life also requires explicit links between university and professionally defined graduate competencies and the design of activities and assessment within the curriculum (Hart, Bowden & Watters 1999). The emergent reality of fluid careers (Starr-Glass 2019) also requires a greater emphasis on the development of metacognitive and reflective abilities in students so that, as graduates, they will have the capability, capacity and confidence to use their personal resources appropriately and flexibly, regardless of environment. Furthermore, universities (and therefore graduates) require a more holistic view of employability skills and their role in strategic career management, lifelong learning and career development of graduates (Bridgstock 2009) including for careers which currently do not exist. Therefore, the work presented here explored academic, student, graduate and industry partner (employer) perspectives on employability skill development and career awareness in Science graduates. We aimed to understand which employability skills are considered important, whilst also gauging perceived levels of attainment and confidence in those skills. This knowledge will facilitate updates to the Science curriculum to address any gaps and ensure graduates are career ready.

Methodologies

This project, approved by the University of Adelaide's Human Research and Ethics Committee (H-2022-145), used online surveys (administered via Survey Monkey), in-person paper surveys, focus groups, interviews and workshops to collect data on perspectives on employability skills and career awareness from academics, students, relatively recent graduates (within the last 6 years) and employers of Science graduates (referred to as industry).

Surveys
The online survey of academics asked demographic questions (gender, number of years teaching and level of teaching) (Table *1*) as well as Likert scale questions to rate the importance of skills/attributes to be attained by students (where '1' was not important at all and '5' was extremely important) and academics' own confidence to teach each skill/attribute (where '1' was not confident at all and '5' was extremely confident). The evaluated skills/attributes are shown in Table *2* and were derived after consideration of those listed by other authors (Prinsley & Baranyai 2015; World Economic Forum 2020; McGunagle & Zizka 2020, Rayner & Papakonstantionou 2015; Sarkar et al 2016). The survey was completed by 30 academics from at least 8 Australian institutions (where identified by participants). Most academics had substantial experience and taught either undergraduate only or both undergraduate and postgraduate Science students (Table *1*).

The in-person and online survey of students and online survey of graduates asked demographic questions (gender, age, degree studied and what year of their degree they were in/ how many years they have been working in their area/industry) (Table *1*) as well as using Likert scale questions similar to those used for academics. Students and graduates were asked to rate the importance of skills/attributes (as per Table *2*) in preparing them for graduation/career; and their own confidence in having developed each skill/attribute. However, for graduates, the skills/attributes list was shortened (due to concerns relating to the length of the survey) so that the more specific academic skills were combined (Table *2*). Students and graduates were also asked at which stage in their studies they considered potential career pathways; whether plans about their career pathway changed during (or following) their studies (and if so, what influenced them). The survey was completed by 149 students from three institutions (with n=144 from the University of Adelaide). Students were from a range of science degrees including agricultural science, general science, wildlife conservation, biotechnology and biomedicine. The majority of students were aged 18-20 years old and were in the first year of their degree (Table *1*). The survey was completed by 35 recent graduates with significantly more graduates being from a general science degree, female, aged between 21 and 25 years old and in industry for less than one year (Table *1*).

Table 1. Demographics of survey participants

Academic

Category		
Gender	*Female*	15
	Male	14
	Prefer not to say/Other	1
Level	*UG#*	12
	PG	2
	Both #	14
	Neither	2
Years	*<5*	4
	5-10	2
	11-15	7
	16-20	6
	>20	11

Student

Category		
Gender	*Female*	75
	Male	70
	Prefer not to say/Other	4
Age	*18-20#*	106
	21-25	30
	26-35	12
	35+	1
Area/ Sector*	*Sc*	19
	Ag	74
	Vet or Wild	24
	Biotech	13
	Physiol or Biomed	9
	Other!	4
Level	*1st#*	101
	2nd	20
	3rd	25
	≥4th	3

Recent Graduate

Category		
Gender	*Female #*	25
	Male	10
Age	*21-25#*	21
	26-35	12
	35+	2
Area/ Sector*	*Sc#*	16
	Ag	6
	Physiol or Biomed	8
	Other!	5
Years	*<1#*	16
	1-2	7
	>2-4	7
	4+	5

Industry

Category		
Gender	*Female*	5
	Male	12
Area/ Sector*	*Energy*	2
	Ag#	13
	Biomedical	1
	Analytical Chem	1
Years	*<5*	3
	5-10	3
	11-15	4
	16-20	0
	21+	7

Significantly different categories (P<0.05) in Chi-square test
* Area are categories of degrees for students and graduates defined as Sc = general science degrees; AgSc = Agricultural Science and related degrees such as Horticulture and Livestock Production; Vet or Wild = Veterinary Science, Veterinary Technology, Animal Science and Wildlife Conservation degrees; Biotech = Biotechnology and Chemical Engineering degrees; Physiology or Biomedicine = degrees in Human Physiology; Health and Medical Science or Biomedical Science.
! Other degrees included those in Computing Science, Natural Resource Management, Arts with Science, Applied Biology, Psychological Science, Global Challenges

Table 2. Skills and attributes rated by academics, students, recent graduates and industry in the surveys. For recent graduates and industry, the academic and research-related skills were combined and presented as one skill/attribute.

<table>
<tr><th>Skill/Attribute</th><th>Academic</th><th>Student</th><th>Recent Graduate</th><th>Industry</th></tr>
<tr><td>Knowledge specific to their chosen discipline</td><td></td><td></td><td colspan="2" rowspan="7">Academic and research skills (e.g. discipline-specific knowledge, technology design, data analysis, designing and conducting experiments)</td></tr>
<tr><td>Mathematical skills (numeracy/quantitative skills/statistics)</td><td></td><td></td></tr>
<tr><td>Digital and information technology skills</td><td></td><td></td></tr>
<tr><td>Technology design and programming</td><td></td><td></td></tr>
<tr><td>Location of relevant information from reliable sources</td><td></td><td></td></tr>
<tr><td>Research skills (planning, designing and undertaking experiments)</td><td></td><td></td></tr>
<tr><td>Data analysis and critical thinking to solve complex problems</td><td></td><td></td></tr>
<tr><td>Acknowledge viewpoints of others and respond appropriately</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Effective communication of ideas/data</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Resilience, stress tolerance and flexibility</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Ethical practice</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Working independently</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Working within a team</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Conflict resolution</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Making confident decisions</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Leadership skills</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Effective management of time</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Self-reflection and self-regulation skills (metacognition)</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Creativity, innovation and initiative</td><td></td><td></td><td></td><td></td></tr>
</table>

The online survey of industry representatives asked demographic questions (gender, industry/area worked in, number of years in that industry/area) (Table *1*) as well as questions about their role in overseeing the work of recent Science graduates; and the delivery of specific workplace-ready training of new Science graduates in their workplace. Likert scale questions, similar to those used for graduates, asked industry members to rate the importance of skills/attributes and how well developed each skill/attribute was in recent Science graduates (see Table *2*). The survey was completed by 17 industry members with 16 of the 17 industry participants directly responsible (either fully or partially) for overseeing the work of recent Science graduates.

Where appropriate, data was analysed using chi-square analysis or analysis of variance (ANOVA) with a significance level of 0.05. Responses given on Likert-type scales were analysed as categorical variables (and dependency on certain categories such as male versus female, year level of study). In addition to each category being compared, chi-square analysis was also used after grouping together the most positive and most negative responses (for example, combining together very important and extremely important as more positive than not at all, slightly important and somewhat important). To make comparisons easier, responses to questions with ordinal scales were also recoded into numeric values to determine centralised measures (mean, median and mode) and allow ANOVA. Heat maps were also created using 50% of responses as the midpoint. Data from open response questions was subjected to thematic analysis (and calculation of the percentage of comments categorised to a theme).

Workshops, focus groups and interviews

A total of 34 academics from 11 institutions participated in either one in-person or one online workshop. Participants worked in groups of three to six members to consider *What skills do students need to have gained to be ready for graduation?* for one student scenario before discussing with all workshop participants. Student scenarios were designed to encourage participants to consider the different career pathways and different motivations of students (Figure 1). Participants were then asked to discuss their personal perceptions of confidence and capability in teaching the skills identified by workshop participants, before comparison with the results on confidence from the academic survey, and discussion of possible solutions for any identified roadblocks to the implementation of WIL.

Further discussion about employability skills also occurred at a workshop held with academics at the Australian Conference of Science and Maths Education (2023, with 25 participants from 16 institutions) and at an online co-creation workshop with academics, industry and graduates (n=50 with 11 employers or recent graduates and 39 academics from 16 institutions). These workshops specifically considered the skills and experiences required to be career ready as well as how information about career pathways can be delivered to students.

One-hour focus groups and interviews provided further data on key aspects discussed in workshops and to also involve students. A total of nine students across two focus groups and three academics, three employers and two graduates participated in interviews. Discussion focused on their perception of career pathways, the availability of information about career pathways, which employability skills are important in graduates and useful experiences to develop those employability skills.

Scripts from workshops, focus groups and interviews were subjected to thematic analysis by inductively coding themes and calculating the percentage of comments categorised to each theme (adapted from Braun & Clarke 2012).

Results and Discussion

Perceived importance of employability skills

Generally, there was consensus between student, academic, graduate and industry survey participants about which skills/attributes were considered important for graduates upon completion of their degree (

Figure *2*). Regardless of participant type, there were very few responses indicating that a skill was not at all important. The percentage of participants that chose very important or highly important (more positive when compared with the other categories) was usually significant and often greater than 80%. Analysis by ANOVA and use of the weighted average, mode and median (Table *3*) also helped to differentiate the order of importance of the skills within each stakeholder group of survey participants. Skills/attributes commonly rated as of lesser importance, regardless of group, included technology design and programming, leadership skills and conflict resolution, while effective communication of ideas/data and effective management of time were often rated more positively in terms of importance (Figure *3*, Table *3*).

Charli grew up in the country, loves animals and has always wanted to be a vet. She has just enrolled in Veterinary Bioscience so is making the move to the city to begin studies. She's planning to see how the initial degree goes but has hopes to continue studying and complete a Doctor of Veterinary Medicine.

Laura has been working as a dental nurse for 10 years and has decided that she's ready for a change. Having spent time in the health industry and given the recent pandemic, she's keen to learn more about immunology so has chosen to major in microbiology and immunology.

Matt completed a Cert IV in Conservation and Land Management straight after high school and has been working in the industry for the last eight years. He wants to progress further and needs additional qualifications. He is set on completing a PhD because he loves the research-focused aspects of his current position. He brings a wealth of practical skills, but little knowledge of the ins and outs of academic life.

Simon has just enrolled in a Bachelor of Science. He did well in science subjects at school and a few mates enrolling in science degrees so wanted to join them at uni. Simon is thinking about majoring in environmental science but hasn't decided yet. He figures he'll work out what's next when it comes, but for now he's looking forward to the university lifestyle.

Sally has known since she was 10 that she would complete her doctorate in physics. Her enthusiasm for astronomy has not faulted through her school years and now that she's enrolled in a Bachelor of Science (Space Science and Astrophysics), she's ready to work hard to achieve her academic goals.

Bridget has just finished high school and isn't too clear on what she wants to do in the future. Her grades have always been good, and she's always seen university as a logical next step. She's enrolled in a general science degree but has no idea what she might specialise in, or what she might do with her degree after graduation. At this stage, she is just here to explore her options.

Frank was 2 years into a Bachelor of Commerce but took a year off to reassess his options. During this time, he worked in hospitality and has now decided to enrol in a Bachelor of Science majoring in viticulture and oenology to turn his passion for wine into a career. He hasn't studied science in a while and he's not confident in his abilities. He hopes that he'll study hard to get through the degree and land comfortably in a career in winemaking.

Figure 1. Examples of students given as scenarios when asking academic workshop participants about what skills will need to have been gained by students to be career ready upon graduation

Chi-square analysis revealed that academic perspectives of importance were significantly positive for all skills/attributes except leadership and technology design and programming (only rated as very important and extremely important by 57% and 53% of respondents respectively). Indeed, 6.7% of respondents rated technology design and programming as not at all important. Analysis of variance (ANOVA) of the means (Table *3*) also determined that technology design and programming was considered significantly less important than all other skills except leadership skills. Although not significantly different when comparing the means, the most important skills appeared to be effective communication and location of relevant information. Greater than 90% of academic survey respondents rated effective management of time, location of relevant information as well as data analysis and critical thinking to solve complex problems as very and extremely important.

Greater than 90% of student survey respondents rated working within a team, effective communication and effective management of time as very and extremely important (

Figure *2*). Knowledge specific to the chosen discipline was also rated as significantly more important than other skills (Table *3*). Chi-square analysis showed that the more positive rating of importance was significant for all skills/attributes except technology design and programming (which was only rated very and extremely important by 30% of respondents). Analysis of variance (ANOVA) of the means (Table *3*) confirmed that technology design and programming was considered by students to be of significantly lower importance than all other skills followed by mathematical skills (numeracy/quantitative/statistical) and digital and information technology skills.

For graduates, the ratings of the importance of all skills/attributes were skewed significantly in a more positive manner except for conflict resolution (rated by only 55% of respondents as very and extremely important). The means of the Likert scale for the rating of the following skills were significantly more important (using ANOVA) (**Table 3*****) and rated by more than 90% of graduate respondents as very or extremely important: effective communication, effective management of time and resilience, stress tolerance and flexibility (***

Figure *2*). The importance of conflict resolution was rated significantly lower than all other skills/attributes except for leadership and self-reflection (Table *3*).

More than 90% of industry survey respondents rated effective communication and effective management of time as very and extremely important. Using chi-square analysis, industry perspectives of importance were significantly positive for all skills/attributes except for leadership (only rated by 65% of participants as very and extremely important) (

Figure *2*). When comparing the weighted averages, leadership appeared to be rated as the least important and effective management of time as most important (Table *3*). However, there was no significant difference between any of the skills/attributes for mean importance. These results mostly reflect previous studies, especially with regards to the importance of communication (McGunagle and Zizka 2016, Rayner & Papakonstantionou 2015). However, the effective management of time was ranked more highly in this study, and supports predictions made by employers in a study by Rayner and Papokonstantinou (2015) that time management (termed as personal planning and organisation) would become increasingly valuable.

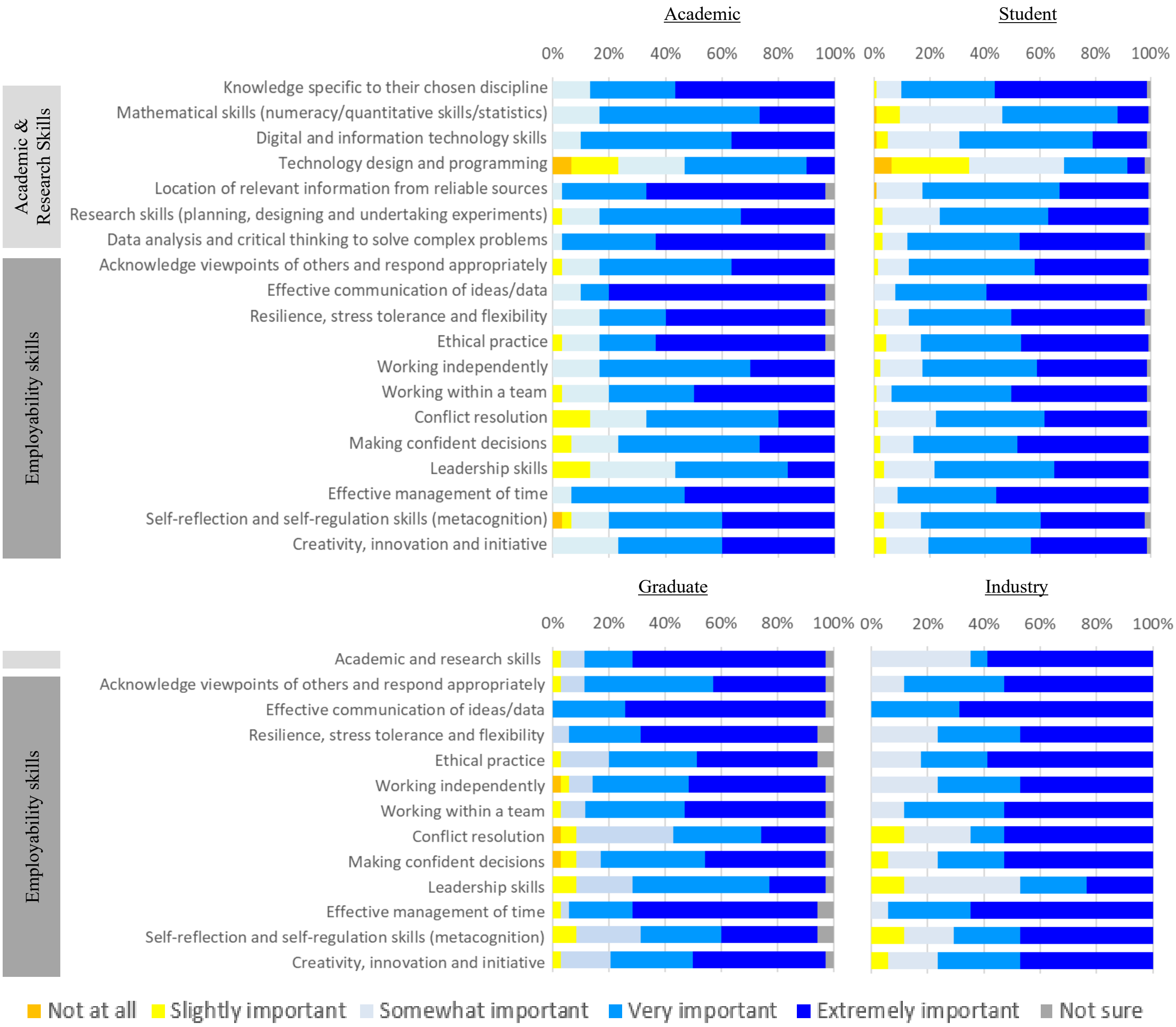

Figure 2. Relative frequencies of responses by academics, students, recent graduates and industry to rate the importance of skills. All survey participants were asked to rate the importance of skills, as listed in Table 2.

Table 3. Central measures of the responses to questions to rate the importance of skills. Survey participants were asked to rate the importance of skills, as per Table 2. Data was converted to numeric Likert-scale values before analysis (where '1' was not important at all and '5' was extremely important). 'Not sure' answers were excluded from analysis. $\overline{X}$, mean; SE, standard error of the mean; M, median; Mo, mode. Different superscript letters denote significant difference between means (within academic, student, graduate or industry responses), as determined by Fisher's LSD (where P<0.05).

		Academic			Student			Graduate			Industry		
		$\overline{X}$± SE	M	Mo	$\overline{X}$ ± SE	M	Mo	$\overline{X}$ ± SE	M	Mo	$\overline{X}$ ± SE	M	Mo
Academic & Research Skills	Knowledge specific to their chosen discipline	4.43±0.13^{fghi}	5	5	4.45±0.06^{ijk}	5	5	4.56 ± 0.13^{efg}	5	5	4.24±0.24	5	5
	Mathematical skills (numeracy/quantitative skills/statistics)	4.10±0.12^{de}	4	4	3.55±0.07^{b}	4	4						
	Digital and information technology skills	4.27±0.12^{defgh}	4	4	3.83±0.07^{c}	4	4						
	Technology design and programming	3.33±0.20^{a}	4	4	2.95±0.09^{a}	3	3						
	Location of relevant information from reliable sources	4.62±0.10^{i}	5	5	4.13±0.06^{def}	4	4						
	Research skills (planning, designing, and undertaking experiments)	4.13±0.14^{def}	4	4	4.10±0.07^{de}	4	4						
	Data analysis and critical thinking to solve complex problems	4.59±0.11^{hi}	5	5	4.31±0.06^{ghi}	4	5						
Employability Skills	Acknowledge viewpoints of others and respond appropriately	4.17±0.14^{defg}	4	4	4.27±0.06^{fgh}	4	4	4.26±0.13^{cdef}	4	4	4.41±0.17	5	5
	Effective communication of ideas/data	4.69±0.12^{i}	5	5	4.51±0.05^{k}	5	5	4.74±0.08^{g}	5	5	4.67±0.12	5	5
	Resilience, stress tolerance and flexibility	4.41±0.14^{efghi}	5	5	4.35±0.06^{hij}	4	5	4.61±0.10^{fg}	5	5	4.24±0.20	4	5
	Ethical practice	4.41±0.16^{efghi}	5	5	4.25±0.07^{efgh}	4	5	4.21±0.15^{cde}	4	5	4.41±0.19	5	5
	Working independently	4.13±0.12^{def}	4	4	4.21±0.07^{defgh}	4	4	4.26±0.16^{cdef}	4.5	5	4.24±0.20	4	5
	Working within a team	4.27±0.16^{defgh}	4.5	5	4.43±0.05^{ijk}	4	5	4.36±0.14^{def}	5	5	4.41±0.17	5	5
	Conflict resolution	3.73±0.17^{bc}	4	4	4.13±0.07^{def}	4	4	3.68±0.17^{a}	4	3	4.06±0.28	5	5
	Making confident decisions	3.97±0.16^{cd}	4	4	4.32±0.06^{ghij}	4	5	4.15±0.17^{bcd}	4	5	4.24±0.24	5	5
	Leadership skills	3.60±0.17^{ab}	4	4	4.09±0.07^{d}	4	4	3.82±0.15^{ab}	4	4	3.59±0.24	3	3
	Effective management of time	4.47±0.11^{ghi}	5	5	4.47±0.05^{jk}	5	5	4.61±0.12^{fg}	5	5	4.59±0.15	5	5
	Self-reflection and self-regulation skills (metacognition)	4.10±0.18^{de}	4	5	4.18±0.07^{defg}	4	4	3.94±0.17^{abc}	4	5	4.06±0.26	4	5
	Creativity, innovation, and initiative	4.17±0.14^{defg}	4	5	4.18±0.07^{defg}	4	5	4.24±0.15^{cde}	4	5	4.18±0.23	4	5

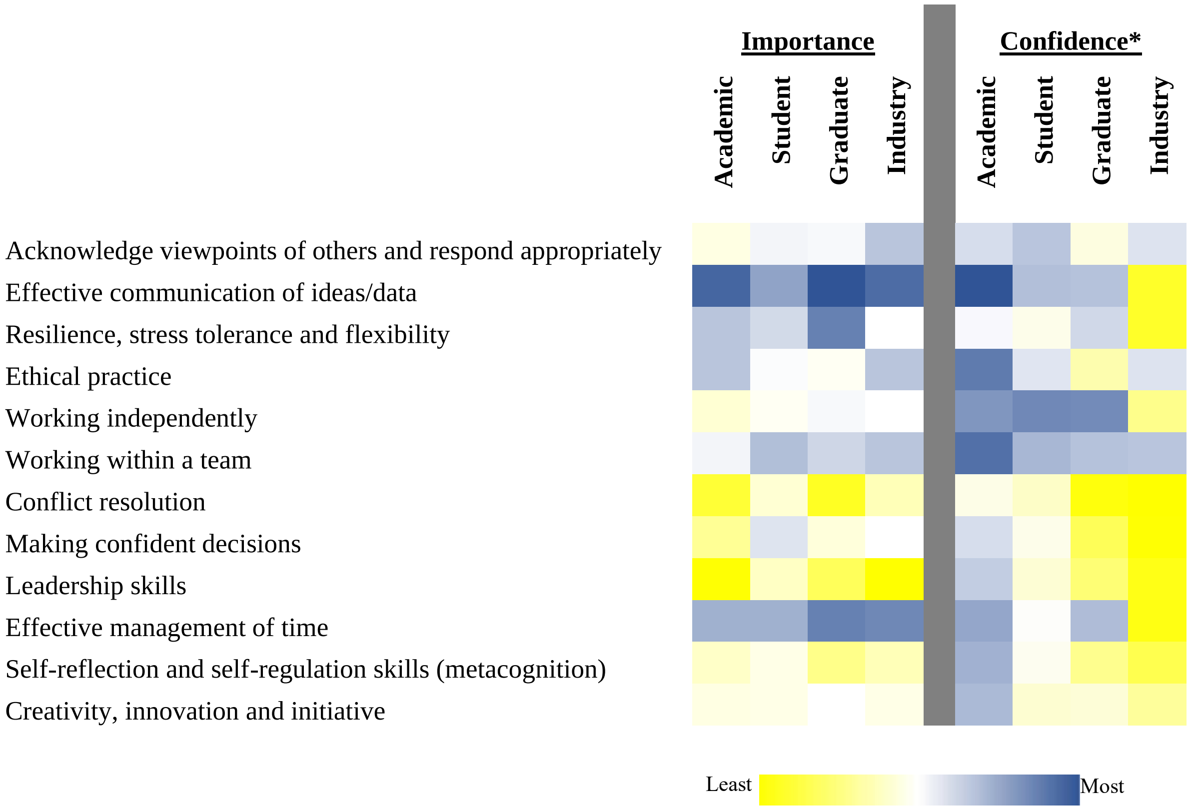

Figure 3. Comparison of ratings for employability skills and their development by academics, students, graduates and industry. All survey participants were asked to rate the importance of skills, as per Table 2. * For Confidence, academics were asked to rate their confidence in teaching of each skill/attribute while students and graduates were asked to rate their own confidence in the development of each skill/attribute. Industry participants rated how well developed each skill/attribute was in recent Science graduates. The heat map was created from data derived from Table 3 and Table 4.

When workshop participants (academics, industry and graduates) were asked to independently list skills important and/or necessary for a Science graduate to have, all skills provided for rating in the survey were listed by participants except creativity, innovation and initiative (Figure *4*). Of these, the most often mentioned skills were academic and research skills, effective communication of ideas/data, self-reflection and self-regulation skills (metacognition) and resilience, stress tolerance and flexibility (Figure 4A). Of the academic and research skills, the most often mentioned were data analysis and critical thinking to solve complex problems followed by research skills (planning, designing and undertaking experiments) and knowledge specific to the discipline (Figure 4B). During workshop discussion of the most important skills, there was acknowledgement that the diversity of student scenarios considered by participants (in Figure *1*) highlighted how different student motivations and life experiences made teaching employability skills difficult to "*pitch correctly*".

Additional skills identified during workshop discussions were defined and categorised by consensus at the workshops as career awareness, learning skills, networking skills, professionalism, intercultural literacy and project management. While these skills could be partially captured in the skills/attributes listed by the survey, workshop participants explicitly indicated they should be considered separately as they often required the combination of skills or had different application. For example, project management could have been categorised as effective management of time, but the consensus was that the required combination of organisational skills, leadership and interpersonal communication, in the context of multiple sets of tasks, was complex and should be explicit.

Figure 4. Skills identified as necessary for graduates of Science (and related) degrees by workshop participants. The size of the box indicates the proportion of comments aligned to a skill/attribute. Percentage also shown. Most of the skills/attributes surveyed (Table 2) were identified as well as some additional skills (indicated with an *) (A). The identification of individual academic and research skills, as per Table 2, are also shown (B).

Furthermore, networking skills are often considered to be communication skills due to the emphasis on interpersonal communication. However, networking is necessary to build an individual's social capital (de Janasz & Forret 2008) through the development and maintenance of personal and professional relationships with others to mutually benefit their work or career (Forret & Dougherty 2001). Networking enables scientists to gain new insights into their work and career development while also exploring potential collaborations (Beasley et al. 2024). Skills required to network might also be acquired when working in a team or be demonstrated through the acknowledgement of the viewpoints of others and responding appropriately. Networking is also positively related to an individual's entrepreneurial self-efficacy (that is creativity, innovation, and initiative) (Tomy & Pardede 2020). In addition, although the original set of skills (Table *2*) mentioned acknowledgement of other viewpoints, this does not specifically capture intercultural literacy. Intercultural literacy includes cultural competence as well as the ability to critically reflect on and bring change about in one's own culture (Ochoa, McDonald & Monk 2016).

More than 10% of comments were categorised as career awareness (Figure *4*). Comments at workshops focused upon the need for students to understand different career possibilities, for example, "*awareness that they don't have to stick exactly to what their degree was - their skills may be more broadly valued (they're too siloed)"*. Successful attainment of career awareness and an ability to make decisions about career direction also requires self-awareness ("*self-reflection on workplace philosophy"*) and a positive attitude (Wise, Charner & Randour 1976).

Positive attitude was also mentioned at the workshops as relevant and necessary for the development of learning skills, also defined as "*learning to learn (how do they know what they don't know?)"* or *"study skills"*. One academic commented that *"My mission is to ban the term 'Soft skills' and show students (and staff) that these transferable/employability skills that they need are actually HARD!! and essential, not optional for a workplace"*.

In addition, a positive, ethical and professional attitude was seen as important for the development of professional behaviour (or professionalism). Discussion focused on how students need to learn how to be part of an organisation and fit with that corporate culture. Participants believed that fitting into the workplace requires students to develop self-awareness, responsibility, agency and to have integrity. Integrity is also possibly covered by the ethical practice attribute (Nillsen 2005).

Confidence in having learnt or in teaching of employability skills

Student and graduate survey participants generally had at least some confidence in the development of skills/attributes (Figure 5). Regardless of whether student or graduate, there were very few responses indicating that a skill had not been developed. However, graduates were significantly less confident than students that they had developed their skills in self-regulation and self-reflection (metacognition), ethical practice, conflict resolution, acknowledging viewpoints of others and responding appropriately, making confident decisions, and leadership. In contrast, graduates were significantly more confident than students that they had developed their academic and research skills, ability to effectively manage time and their resilience, stress tolerance and flexibility (Figure *3*, Table 4).

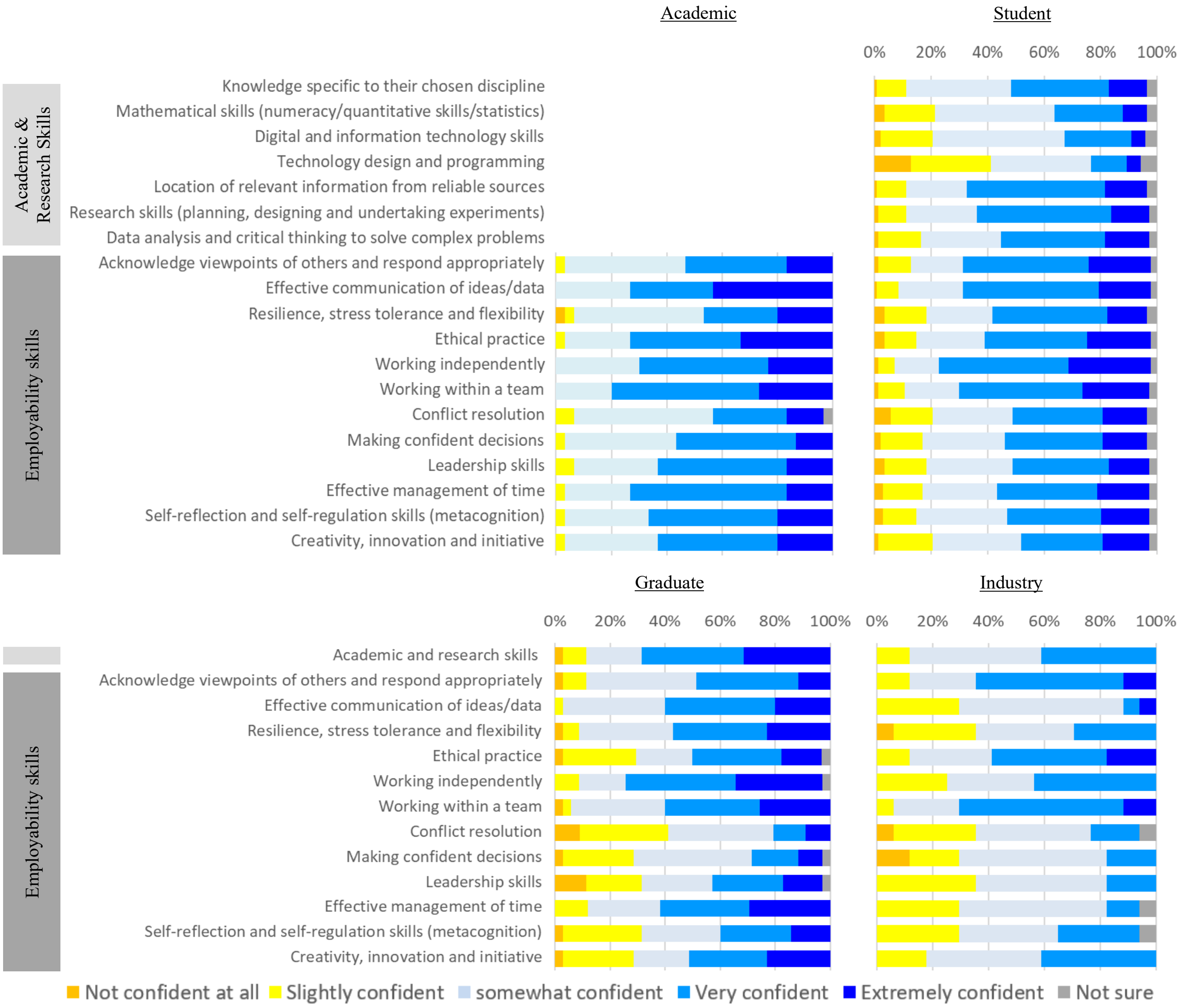

Figure 5. Relative frequencies of survey responses by academics, students, recent graduates and industry to rate the confidence of skills. Survey participants were asked to rate their confidence in their own teaching ability for each skill/attribute (academics), their own confidence in the development of each skill/attribute (students and graduates) or to rate how well developed each skill/attribute was in recent Science graduates. Skills and attributes are as per Table 2

Table 4. Central measures of the responses to questions to rate the confidence of skills. Survey participants were asked to rate their confidence of skills, as per Table 2. Academics were asked to rate their confidence in teaching of each skill/attribute while students and graduates were asked to rate their own confidence in the development of each skill/attribute. Industry participants rated how well developed each skill/attribute was in recent Science graduates. Data was converted to numeric Likert-scale values before analysis (where '1' was not important at all and '5' was extremely important). 'Not sure' answers were excluded from analysis. $\overline{X}$, mean; SE, standard error of the mean; M, median; Mo, mode. Different superscript letters denote significant difference between means (within academic, student, graduate or industry responses), as determined by Fisher's LSD (where P<0.05). N.A. Not asked. Data was also compared using a heat map (Figure 3)

		Academic			Student			Graduate			Industry		
		$\overline{X} \pm$ SE	M	Mo	$\overline{X} \pm$ SE	M	Mo	$\overline{X} \pm$ SE	M	Mo	$\overline{X} \pm$ SE	M	Mo
Academic & Research Skills	Knowledge specific to their chosen discipline	N.A.			3.51 ± 0.08^{cd}	3.5	3	3.86 ± 0.18^{cd}	4	4	3.29 ± 0.17^{bcd}	3	3
	Mathematical skills (numeracy/quantitative skills/statistics)				3.17 ± 0.08^{b}	3	3						
	Digital and information technology skills				3.11 ± 0.07^{b}	3	3						
	Technology design and programming				2.67 ± 0.09^{a}	3	3						
	Location of relevant information from reliable sources				3.69 ± 0.08^{de}	4	4						
	Research skills (planning, designing, and undertaking experiments)				3.64 ± 0.08^{de}	4	4						
	Data analysis and critical thinking to solve complex problems				3.52 ± 0.08^{cd}	4	4						
Employability Skills	Acknowledge viewpoints of others and respond appropriately	3.67 ± 0.15^{abc}	4	3	3.76 ± 0.08^{e}	4	4	3.46 ± 0.16^{bc}	3	3	3.65 ± 0.21^{cd}	4	4
	Effective communication of ideas/data	4.17 ± 0.15^{e}	4	5	3.78 ± 0.07^{e}	4	4	3.77 ± 0.14^{cd}	4	4	2.88 ± 0.19^{ab}	3	3
	Resilience, stress tolerance and flexibility	3.57 ± 0.18^{ab}	3	3	3.49 ± 0.09^{c}	4	4	3.69 ± 0.17^{bcd}	4	4	2.88 ± 0.22^{ab}	3	3
	Ethical practice	4.03 ± 0.16^{cde}	4	4	3.64 ± 0.09^{de}	4	4	3.30 ± 0.20^{b}	3	4	3.65 ± 0.23^{cd}	4	4
	Working independently	3.93 ± 0.14^{bcde}	4	4	3.98 ± 0.08^{f}	4	4	3.97 ± 0.16^{d}	4	4	3.19 ± 0.21^{abc}	3	4
	Working within a team	4.07 ± 0.13^{de}	4	4	3.81 ± 0.08^{e}	4	4	3.77 ± 0.16^{cd}	4	4	3.76 ± 0.18^{d}	4	4
	Conflict resolution	3.48 ± 0.15^{a}	3	3	3.38 ± 0.10^{c}	3	4	2.79 ± 0.18^{a}	3	3	2.75 ± 0.21^{a}	3	3
	Making confident decisions	3.67 ± 0.14^{abc}	4	4	3.49 ± 0.09^{c}	4	4	3.03 ± 0.17^{ab}	3	3	2.76 ± 0.22^{a}	3	3
	Leadership skills	3.73 ± 0.15^{abcd}	4	4	3.42 ± 0.09^{c}	3	4	3.12 ± 0.21^{ab}	3	4	2.82 ± 0.18^{ab}	3	3
	Effective management of time	3.87 ± 0.13^{abcde}	4	4	3.54 ± 0.09^{cd}	4	4	3.79 ± 0.17^{cd}	4	4	2.81 ± 0.16^{ab}	3	3
	Self-reflection and self-regulation skills (metacognition)	3.83 ± 0.14^{abcde}	4	4	3.51 ± 0.09^{cd}	4	4	3.2 ± 0.19^{ab}	3	3	3.0 ± 0.20^{ab}	3	3
	Creativity, innovation, and initiative	3.8 ± 0.15^{abcde}	4	4	3.41 ± 0.09^{c}	3	3	3.43 ± 0.20^{bc}	4	4	3.24 ± 0.18^{abc}	3	4

Greater than 65% of student respondents were very confident or extremely confident that they had developed their ability to work in a team and independently, effectively communicate, locate relevant information from reliable sources and acknowledge the viewpoint and respond accordingly to others. Chi-square analysis showed that the more positive rating of confidence was significant for all academic and research skills/attributes except mathematical skills, digital and information technology skills, and technology design and programming skills. Only 34% of students were very or extremely confident with their mathematical skills, 30% with their digital and information technology literacy and 19% with their technology design and programming. Students' confidence was significantly positive for all employability skills except creativity, innovation and initiative (with a very or extremely confident rating for 47% of respondents). Analysis of variance of the weighted means (Table 4) confirmed that students considered themselves less confident with mathematical skills, digital and information technology skills, technology design and programming skills as well as creativity, innovation and initiative. When considering the impact of demographics on responses, male students were significantly more confident than female students for all skills except working independently, effective communication of ideas and data, self-reflection and self-regulation, and creativity, innovation and initiative. Male students were significantly less confident in effective communication of ideas and data (data not shown).

The ratings of graduates' confidence were significantly skewed in a positive manner for the following skills/attributes: academic and research skills, working independently and within a team, effective communication of ideas and data, effective management of time and resilience, stress tolerance and flexibility (Figure *3*, Figure 5). Only 21% of graduates were very or extremely confident in their conflict resolution skills and 26% for making confident decisions. The weighted averages for graduate confidence in the development of leadership skills and self-reflection and self-regulation skills were also significantly lower (Table 4).

Generally, academics were confident in their abilities to teach employability skills (Figure 5). Results from ANOVA and the use of the weighted average (Table 4, Figure *3*) indicated that academics were least confident in their abilities to teach conflict resolution as well as resilience, stress tolerance and flexibility. Chi-square analysis confirmed that academic perspectives of confidence to teach were significantly positive for all employability skills/attributes except conflict resolution; making confident decisions; resilience, stress tolerance and flexibility; and acknowledge viewpoints of others and responding appropriately (only rated as very confident or extremely confident by 41%, 57%, 47% and 53% of academics respectively). Students in the focus groups also acknowledged the difficulty with teaching these skills, noting that they would learn conflict resolution *"by the example set by academics resolving groupwork issues for us"* and "*resilience is a hard one to teach but I have to deal with the number and feedback on assignments anyway"*. Effective communication of ideas/data, working within a team, effective management of time and ethical practice were often rated more positively in terms of confidence to teach (>70% of academics were very confident or extremely confident) (Figure 5, Table 4).

Attainment of employability skills

When considering whether graduates had developed certain skills/attributes (as per Table *2*), the ratings by industry were significantly skewed in a positive manner for ethical practice, working within a team and acknowledging viewpoints of others and responding appropriately, with 59%, 75% and 65% of respondents rating these as very well developed or extremely well developed (Figure *3*, Figure 5). Chi-square analysis also revealed that ratings were skewed negatively for effective management of time and effective communication of ideas and data with only 13% and 12% of respondents rating these as very well or extremely well developed. When comparing the weighted averages, conflict resolution and making confident decisions appeared to be the least significantly well developed in graduates while the significantly most well developed is working within a team (Table 4). Employers in a study by Sarkar et al (2016) also identified that independence, leadership skills and using initiative were not as well developed as they could be.

The observation by industry that graduates had well developed teamwork skills aligns with graduates' own confidence in the development of teamwork skills and the confidence of academics to teach teamwork (Figure *3*). However, even though graduates were confident that they had developed effective communication of ideas and data, effective time management, ability to work independently as well as resilience, stress tolerance and flexibility, industry did not believe these were well developed in graduates.

Given that effective communication was considered as one of the most important skills by all groups (

Figure *2*, Figure *3*) and academics felt most confident in teaching this skill (Figure 5), some industry participants were asked to elaborate on their perceptions during the workshops and interviews. While the ability of students to prepare scientific manuscripts was acknowledged as well developed, comments suggested that students have not had enough experience in presenting to different audiences *"especially lay or users of science with no background in science"* and that the modes of communication learnt by students needs to be expanded to "*interacting with others with different world views*", *"social media"* and to "*the working business environment requirements"*. Interestingly, and related to these communication skills, graduates did not feel confident in how to acknowledge viewpoints of others and respond appropriately (Figure *3*, Figure 5).

Most industry survey participants (65%) indicated that they offered specific work-readiness training to newly recruited Science graduates. This training was quite varied, ranging from a structured 3-year program (including rotations between different jobs in the company and job skills training) to encouragement to attend industry events and meetings ("*to build confidence and critical thinking skills"*). Many employers also offered initial compulsory business readiness/compliance training such as defensive driver training, chemical certification and working at heights certification. Some employers also offered mentorship programs with established researchers/staff to "*build professional development plans (including conference attendance, presentation of data, etc)"*. For one respondent, a perceived decline in graduate learning outcomes resulted in the development of a graduate program in their workplace ("*skills are barely developed in graduates compared to their predecessors. Subsequently, we have evolved a Graduate Program"*). This graduate program has an emphasis on *"ensuring vocational competency is developed in terms of understanding and applying the scientific process"*.

Knowledge of career pathways

Most student survey participants had considered their career pathway following the completion of their degree (85%). Of the students who had not yet considered their career pathway (15%), most were first year students. Of those who had considered their future career, significantly more students had thought about their future career pathway before enrolling (60%). However, 48% of students indicated that their career plans had changed during their studies. Although female STEM students have previously been reported to have greater career awareness

(Ananthram, Bawa, Bennett & Gill 2024), there was no significant difference in the nature of the responses from male and female students in our study. The most coded theme to explain change in career pathway was a change in the understanding of certain topics/subjects and therefore a change in interests (see Table 5, 54% of open comments). Other significant themes included the opportunity to participate in placements (or similar) and opportunities to learn directly from alumni and industry (Table 5).

Of the graduate survey respondents, 91% indicated their career pathway plans had changed during or with their graduation from their degree. As with the student responses, the most coded theme to explain this was a change in understanding of subjects/topics and interests. Interactions with industry both within their studies and in extracurricular environments were next most important (Table 5). Some graduates also commented on a lack of information on career pathways:

- *"find it's quite hard and don't receive much support in terms of how to go about finding a science job after you graduate"*
- *"there's a real lack of understanding by undergraduate students as to the direction their degree can take them and/or a lack of teaching about how their qualifications translate into industry. I think often-times, course leaders forget that most students are young adults (or even children) who are relying on you to give them the information they need to make these decisions".*

Students in the focus groups confirmed a lack of knowledge about career pathways as well as their own concerns about the transferability of their skills (Table 6). Students indicated that they did not have enough industry interactions during their degree to truly appreciate the different jobs and careers available to them. They also articulated concerns about understanding the expectations of employers, the process of employment itself and how to know what career-readiness skills they had learnt during their degree. A desire for further development of job/career skills to help students identify and apply for jobs as well as to make the transition to the workforce successfully was also recently reported for Chemistry students (Hill, Overton, Thompson, Kitson & Coppo 2019).

Table 5. Themes from student and graduate open comments regarding what has influenced a change in their career pathway. Comments from the survey were coded and % of responses coded to that theme determined.

Theme	Description	Students		Graduates	
		%	Example Quotes	%	Example Quotes
Content	Understanding what different topics involve and whether they enjoy or not	54	• Took a variety of classes and discovered new interests. • Exposed to options through different courses - different courses brought about new interest and career ideas. • New subjects were interesting. I created a new passion.	52	• Once I actually worked in that field, I decided I didn't overly like it and went in a different direction. • I discovered a different field of research that I was more interested in than the field I originally intended to go into • Engaging teachers influenced this change.
WIL	Placements and research projects	14	• When I got a chance to experience real things. I realised that maybe what I thought, is not suitable for me. • Uni and my experience in the workplace (doors opened through uni) has shown me the fantastic breadth of opportunities and further learning opportunities that exist in the workplace. Most importantly uni has given me confidence to grab and pursue these opportunities.	6	• Wasn't overly sure of what I wanted to do after finishing until I completed a summer research scholarship.
Industry linkage	Industry and professional advice, learning about other jobs in classes (e.g field trips)	24	• Listening to guest speakers at career nights and finding new opportunities. • Exposure to more parts of the industry. • Exploring other options, talking to past graduates.	33	• Speaking with counsellors at the university, being exposed to different career pathways I didn't previously know existed. • Exposure to different industries and topics in lectures and guest lectures. • I was influenced most by guest speakers. • Talking to academics and learning about their career pathways. • Began speaking with a large variety of people about their experiences in science leading them to where they are now. Overall, these conversations allowed me to see other career opportunities. • This was all through extra-curricular activities, nothing taught at university. • I never planned to study a post graduate degree but was encouraged to do so for better career prospects.
Other	Degree structure, workload and personal situations	8	• Learning more about the degree and what majors were available/where the later years of the degree are headed; made me rethink if it's actually the career I want!	9	• Entering into a long-term relationship so not wanting to travel too far.

Table 6. Themes from student focus group discussions about career pathways

Theme	Description	Example quotes
Understanding	Lack of knowledge of career types, employer expectations and the process of employment	• How do I get from point A which is graduation to point B, which is career? • I feel like I've got zero ideas. You know. Where do I go after the graduation? • Do I keep working with the same company? Do I bounce onto another? What are their expectations?
Translation	Not able to see transferability of skills across disciplines or within a discipline and an inability to articulate	• How do I translate my skills in this nature to something that might be similar? • I don't even know what I could do with my skills I (have) learned.
Improvements	Direct industry interaction, career expos, facilitation of industry interactions and placements	• Giving us an idea of what's out there and how particularly you're able to put the degree to use or rather, even if there isn't a direct use, how to use the skills students have in the broader sense. • The more different trajectories you're exposed to the more ideas you have about what could be in the future. • Talk about career development. • They've all gone such a different way. It's more about making sure you've got enough examples to see. • Having potentially more connections to those people that you can have conversations with like you obviously need to have that conversation and ask the questions specific to yourself. But you need to have those opportunities. • Second year or later for direct industry interaction. If they talk to you (earlier in your degree) about something they're really passionate about and you don't know anything about it, it's really sad and they won't really start a conversation.

Conclusion and further research

In conclusion, our findings confirm the competence-based dimensions of employability suggested by Römgens, Scoupe & Beausaert 2023: disciplinary knowledge and skills that enable graduates to perform a given occupation (or maintain a relevant job that uses those knowledge and skills); social skills, including networking; ability to continue learning and pro-actively adapt to changing situations and environments; and metacognitive skills to reflect upon goals, values, ambitions and career identity.

In general, the ranking of the importance of employability skills was similar regardless of stakeholder group. Effective communication, effective management of time and working within a team were commonly deemed most important while all groups ranked leadership skills and conflict resolution as of lesser importance. However, industry representatives felt that ability to work independently, effectively communicate and time management skills were least likely to have been attained by Science graduates even though most graduates indicated they were more confident that they had these skills and academics indicated they were more confident to teach these skills. Other recent reports support our observation that employers perceive a lack of some career-readiness and workplace skills in Australian graduates (Bennett, Knight, Bawa & Dockery 2021) and Science graduates (Prinsley & Baranyai 2015; Deloitte Access Economics 2014). Therefore, it is imperative that institutions teaching undergraduate Science (and related degrees) improve curricula and address the observed discrepancy in perceptions. 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. We therefore recommend that the following skills should be prioritised in the first instance: effective management of time; resilience, stress tolerance and flexibility, effective communication, especially interpersonal communication; working independently and making confident decisions; creation, innovation and initiative (entrepreneurship); and leadership skills.

Challenges to the inclusion of more employability skill development in the curriculum will likely include the inflexible structure and nature of the existing curriculum as well as a lack of access to resources and capacity. Therefore, our future directions will focus on the co-creation (with industry) of solutions to meet the challenges in implementing WIL in Sciences curriculum. 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). Frameworks will also be developed to describe the development of activities and aligned assessment geared towards improved delivery and attainment of employability skills and career awareness.

Acknowledgements

This research was funded by the Australian Council of Deans of Science. Many colleagues, industry partners, students and alumni have contributed to this project through participation in surveys, workshops, interviews and focus groups. The project would not have been possible without their contributions.

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