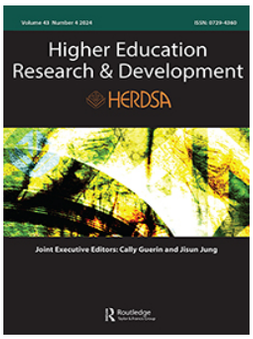

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Stakeholder perceptions of what industry wants from doctoral students: a systematic literature review

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ABSTRACT

An increasing mismatch between the global supply of PhD-qualified graduates with the global demand within the tertiary education sector comes despite academic positions remaining graduates' first choice of future career. The 'silver medal' choice, research work in industry, is increasingly a likelier outcome, leading to a need to understand industry employers' perspectives on desirable graduate attributes. This study systematically synthesises the results of literature examining industry employer perspectives, contrasting those perspectives with both the perspectives of PhD students and PhD-qualified graduates working in the industry. The findings show relatively little published empirical research to inform the transition of PhD graduates to industry destinations. Current research, however, indicates industry employers and those working in the industry tend to prioritise teamwork and collaboration more highly than doctoral students and shows that critical thinking is a skill set that unifies the views of employers, those working in industry, and doctoral students.

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Introduction

The PhD is widely regarded as the apex academic qualification, but a qualification to what end? The answer logically and empirically appears to be determined by a range of factors including discipline area (a PhD in 'what'?), and national and institutional variations. The findings of the global *Nature* PhD Students Survey indicate most doctoral students still dream of a job in academia (56%), a proportion double that of industry (28%), with the balance almost equally divided between seeking roles in medical, government and non-profit sectors (Woolston, 2019). The dream for most is statistically unlikely to come true. In the last decades, an over-production of qualified doctoral graduates has arisen, with an increase in PhD intakes and a decrease in the number of academic

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employment opportunities (Brown & Mountford-Zimdars, 2017; Valencia-Forrester, 2019).

In almost all OECD countries, there has been a significant annual increase in the numbers of graduates with doctoral degrees, particularly amongst women. Growth of numbers exceeded 10% in countries such as Portugal, Italy, and Denmark (Auriol, 2010), outstripping demand for tenured academic jobs. McCarthy and Wienk (2019) showed the number of PhDs started outstripping the number of academic placements in Australia in the 1990s, so this problem has been of long duration. Even in 1995, a commentary in *Nature Medicine* declared bluntly 'too many scientists, too few academic jobs' (Kerr, 1995) and these academic roles, at least in some of the OECD countries such as Canada (Willson & Julien, 2020) and Australia (May et al., 2013), are increasingly precarious – casual or short-term contract in nature. What then of roles in the 'silver medal' choice of PhD graduates: industry? This paper examines the perceptions of three categories of stakeholders in the PhD-to-industry pipeline: industry employers, PhD graduates working in industry, and PhD students. We conduct a systematic literature review to advance the question: what characteristics make a tertiary-trained researcher employable in industry, and do PhD students have an accurate perception of the expectations of industry?

Employability

Even for PhD students in fields with a clear connection to industry priorities, the path from graduate schools to the industry is surprisingly lightly travelled. In the US, around 9000 students graduate with doctoral degrees in the biomedical sciences but only 18% of them end up in industry (Cutler, 2018). At the other extreme, the US Bureau of Labor Statistics uncovered thousands of doctoral graduates in low-paid front-line service roles (Group of Eight, 2013), not always against their will but contrary to the arc of their training. Graduates with doctoral qualifications that appear on the surface to offer a 'natural' fit to industry jobs – those with degrees in engineering, science, and health – are rarely *unemployed* (Vitae, 2013) but their employment may not be commensurate with the length. quality or nature of their education and training.

While the pool of academic roles is relatively focused and finite, there is a much larger, broader range of employment opportunities in the silver and bronze choices of PhD scholars: industry, non-profit, and government roles. The PhD program, arguably, offers an attractive package to employers: the completion of a PhD would, *a priori*, seem to require persistence, self-direction, creativity, critical thinking, and communication skills. Mewburn et al. (2020) used a machine learning approach to analyse almost 30,000 job ads from a popular Australian job search website (which the authors concede was skewed to the managerial and highly paid end of the job spectrum). They sought to explore the level of density of research skills in advertised jobs, finding that a surprising 25% of employers were seeking what the authors termed a 'PhD-shaped' applicant. Working in the same employment market, McCarthy and Wienk (2019) found that 19 of the 20 largest Australian Stock Exchange-listed firms had PhD graduates in their senior executive teams. They found that the banking, finance, and insurance industries are the top employers of PhD graduates, followed by mining oil and energy and the medical/pharmaceutical industry, a result mirrored in other global markets (Reithmeier

et al., 2019). Thus, while the PhD was designed to both train and credential the academic workforce (Mewburn et al., 2020), it is clearly capable of doing more.

Equally, there is evidence that doctoral training is capable of doing more to improve graduates' adjustment and employability outside the university sector (Jackson et al., 2019). As such, there has been an increase in research focus on broader employability attributes of PhD graduate students and the skills required to ensure they are prepared for employment outside the tertiary sector. Universities are offering more 'bolt-on', semi-formal programs o\ffering doctoral students training centred around skills transferable to industry or, more broadly, employability skills (Patricio & Santos, 2019). Nevertheless, scholars have argued that employability and university programs tend to be predominantly focused on STEM PhD graduates (Kiley, 2014; Patricio & Santos, 2019) with little research to date focused specifically on PhD graduates in the humanities, social sciences, and business.

This paper offers insight into the literature that has emerged around the notion of employability skills of PhD graduates transitioning from the world of tertiary research training to industry. By highlighting the extent and type of literature being published on preparing PhD graduates for industry, we can offer insight into the knowledge gap as well as summarise what characteristics are perceived to make a tertiary-trained researcher employable in industry.

Methods

This systematic literature review critically assesses research on PhD employability, focusing on employability skills required by doctoral students entering non-academic jobs, specifically in industry.

Search strategy

To assess the literature for skills related to PhD employability in non-academic sectors, we conducted a systematic literature review following methods suggested by Pickering and Byrne (2014). An electronic database search was conducted initially in January 2021 (subsequently updated to October 2021) querying electronic databases: Scopus (Elsevier interface), Proquest, Business Source Complete (EBSCO interface), Emerald Fulltext (Emerald Publishing interface), and Web of Science. Business Source Complete and Emerald Fulltext are prominent business databases while Proquest, Scopus, and Web of Science are multidisciplinary and provide a broad and encompassing search (Burnham, 2006).

Key search terms were 'PhD OR doctorate' combined with 'employability OR industry', limited to title and abstract, and published in the English language. The timeframe for the search was restricted to the past 10 years because of the rapidly changing landscape: as noted earlier, the proportion of doctoral graduates entering traditional academic roles is rapidly reducing.

An initial search was conducted, and duplicates were removed. The remaining unique articles were examined for relevance guided by inclusion and exclusion criteria in Table 1. The first scan involved reading the title and abstract and indeterminate studies were examined in full text. To complement the initial search, reference lists of articles which met the

Table 1. Inclusion/exclusion criteria.

No.	Criteria
1	**Included**: Papers employing primary research, including qualitative, quantitative, and mixed methods research **Excluded**: Theses; editorial, opinion, or theoretical paper; meta-analyses, literature reviews; and conference presentations
2	**Included**: Papers that specifically focus on some aspect of ***industry*** employability skills **Excluded**: Papers that focus exclusively on ***academic*** employability skills
3	**Included**: Papers that investigated employability of doctoral students or graduates **Excluded**: Papers that investigated employability of students or graduates of non-doctoral programs such as undergraduate or master programs; papers that investigated employability skills in general

selection criteria were examined to identify additional relevant articles. These screenings were undertaken by at least two of the authors independently. As an added measure to ensure an exhaustive search, Google Scholar was searched using combined terms of 'employment AND PhD', 'employment AND doctorate', 'industry AND PhD', and 'industry AND doctorate'.

Screening

The initial search yielded 1340 documents. Duplicates were removed, resulting in 1017 unique articles for further investigation. Titles and abstracts were reviewed independently by two reviewers resulting in the elimination of 962 papers which did not meet the selection criteria. Full-text manuscripts of the remaining 55 studies were retrieved and examined against inclusion/exclusion criteria. The full-text review, conducted by two independent reviewers, resulted in the elimination of 46 studies. Reference lists of the remaining nine studies were independently examined by two reviewers for relevance to selection criteria. Seven articles were identified by title for further examination. Full-text manuscripts were examined and five were excluded as they did not meet inclusion/exclusion criteria. An additional Google search revealed no new studies met the inclusion criteria. In conclusion, 11 primary studies were included in the systematic review. The PRISMA chart is available on request.

Results

Quality appraisal

Research questions posed by the studies in this review were of an investigative or exploratory nature and were addressed by asking questions of participants rather than observing the referent phenomena. Data was collected by self-report and/or interviews, and data analysis was typically descriptive, or at best, involved group mean comparisons. The studies did not use standardized instruments meaning alignment of skills findings between studies was difficult, and in some cases, the list of skills included were generic and broad. Few of the studies fully revealed sampling methods or response rates.

The Methodological Quality Questionnaire (MQQ) rating scale (Acosta et al., 2020) was applied to the papers. The MQQ assesses characteristics of descriptive research most likely to influence the reliability and validity of the study conclusions, such as clear research aim, relevant study design, and appropriate sample selection and recruitment. We excluded two of the characteristics (implications for practice and policy), as the

focus of this study was identifying employability characteristics, rather than other applied implications. Scores for the two excluded criteria were however high across all studies.

The results of the quality analysis are available from the corresponding author on request. Overall, the quality of the articles was highly variable, rating from 9 to a perfect score of 21. Quality indicators were lowest for evidence of validity and/or reliability of measurement tools, followed by the description of sampling methods and sample characteristics.

Descriptive analysis

A standardised form was used to extract data from the 11 selected studies (see **Appendix A**). Data extraction was completed by one reviewer and verified by another. Following is a summary of demographic characteristics of the studies including methodology, academic discipline, industry, and country.

Geographic distribution

Our analysis of geographic distribution of articles concerned with doctoral employability revealed predominantly Western societies. There was a mix of studies from European countries ($n = 4$; De Grande et al., 2014; Haapakorpi, 2017; Kyvik & Olsen, 2012; Shmatko, 2016), Australia ($n = 4$; Jackson et al., 2019; Jackson & Michelson, 2016; Manathunga et al., 2012; Mitic & Okahana, 2021), and USA ($n = 2$; Cui & Harshman, 2020; Sinche et al., 2017) and one study across multiple countries (González-Martínez et al., 2015). We acknowledge limiting searches to the English language may have skewed the output.

Discipline fields and industry groups

Multiple academic discipline fields and industry types were represented in our results. Only three studies specifically targeted discipline fields: two involved the sciences (Jackson et al., 2019; Sinche et al., 2017) and one chemistry (Cui & Harshman, 2020) (see Table 1).

Sample

Only four of the studies examined the viewpoint of industry employers or managers of staff (De Grande et al., 2014; González-Martínez et al., 2015; Haapakorpi, 2017; Shmatko, 2016), resulting in a subsample of 642 individuals between the four papers. The overall sample of employed or unemployed doctoral students in the combined 11 papers was 18,830. The papers also collectively included data from 212 doctoral students.

Methodological approach

Most papers used a quantitative approach, with two studies employing a mixed method approach (De Grande et al., 2014; Shmatko, 2016) and two studies using an exclusively or almost exclusively qualitative approach (Cui & Harshman, 2020; Haapakorpi, 2017).

Aims, skills, and key findings

Details of the aims, skills identification process, and key findings of included studies are presented in Appendix B. Broadly, the aims of the studies included identifying the knowledge and skills linked to employability outside academia.

Employability skills analysis and findings

We conducted an analysis of the papers to determine the employability skills perceived as important in the industry, from the perspective of three different stakeholders identified in the study: employers, PhD graduates working in industry, and PhD students. This involved cataloguing employability skills identified as associated with the industry sector. Industry-specific data (as distinct from skills relevant to academic roles) could not be extracted from Sinche et al. (2017) reporting and therefore the study was excluded from the analysis. Also excluded were Jackson and Michelson (2016) who reported a composite construct of 'generic skills' which could not be disaggregated. Where possible, skills of a similar nature were grouped together (Table 2). For example, critical thinking, analytical thinking, systematic thinking, and critical judgement were grouped into a category called 'critical/analytical thinking'. In total, 40 unique skills were identified. The skills were then sorted into order of perceived importance in the industry sector (as rated or ranked in included papers). The order was determined according to the sum of studies that identified each skill (possible maximum of nine studies), with higher frequency indicating greater importance. Of the 40 unique skills, eight were identified by four to eight studies, 16 by two to three studies, and 16 by one study. The top eight skills identified through this analysis were: critical/analytical thinking, communication, technical knowledge, planning and organization, research skills, teamwork/collaboration, leadership, and teaching skills.

We further assessed the eight top employability skills to compare the perceived level of importance in the industry sector from three perspectives: (1) industry employers; (2) PhD-qualified employees; and (3) PhD students. Order of importance could not be extracted from Mitic and Okahana (2021) and therefore the study was not included in this last stage of analysis. The sample contributing to rankings included 317 industry employers, 2957 industry employees who were PhD graduates, and 212 PhD students in industry-orientated programs. The final ranking was determined by calculating an average across the studies. For example, *five* studies ranked employees' perceptions of 'critical/analytical thinking' as an important employability skill. We calculated a sum score of the order of importance as ranked by the five studies, i.e., first (Kyvik & Olsen, 2012), third (Haapakorpi, 2017; Manathunga et al., 2012), fourth (Shmatko, 2016), and eighth (Cui & Harshman, 2020). The sum score ($1 + 3 + 3 + 4 + 8 = 19$) was divided by the number of contributing studies ($n = 5$) resulting in an average ranking of 3.80 for employees. This calculation was replicated across each of the skills and stakeholder groups. The scores generated for the eight employability skills ranked according to the priority identified by each of the three stakeholder groups are illustrated in Figure 1.

Discussion and conclusion

Semi-formal and idiosyncratic, doctoral education takes place in relative secrecy, often arising in an informal manner in interactions between supervisors/advisors and students – leaving the 'curriculum' of such training in what Ehrenberg et al. (2007) call a 'black box'. There is relatively little published empirical research to inform the transition of PhD graduates to industry destinations. The 'black box' remains opaque. The subject of PhD employment in industry has attracted insufficient scholarly attention, perhaps

Table 2. Top eight skills categories and the terms used in the literature.

Skill	Terms used in literature	First author
Critical/analytical thinking	Critical thinking	Cui
	Analytical thinking	De Grande
	Analysis and knowledge acquisition	Haapakorpi
	Systematic/analytical thinking	Kyvik
	Critical judgement and analytical skills	Manathunga
	General analytical skills/creative thinking	Shmatko
	Critically analysing and evaluating	Mitic
	Analytical skills	Jackson, D
Communication	Communication skills	Cui; Shmatko; De Grande
	Advanced communication	Jackson, C
	Effective oral/written communication skills	Manathunga
	Communicate effectively to a broad audience	Gonzalez-Martinez
	Communicate ideas clearly and persuasively to a variety of audiences	Mitic
	Written communication	Jackson, D
Technical knowledge	Technical knowledge	Cui
	Scientific knowledge	De Grande
	Industry/profession-specific competence	Haapakorpi
	Industry sector knowledge	Jackson, C
	In-depth knowledge of field of study	Manathunga
	Solid fundamental education in science	Shmatko
	Theoretical training	Kyvik
	Theoretical and practical understanding of subject area and its wider research context	Mitic
Planning/ organization	Management skill & Planning and organizational skill	Cui
	Project management	De Grande; Kyvik
	Management and coordination skills	Haapakorpi
	Insight in project planning & Insight in research management	Kyvik
	Planning	Jackson, D
Research skills	Research skills	De Grande; Shmatko
	Research competence	Haapakorpi
	Methodological training	Kyvik
	Formulate and apply solutions to research problems and effectively interpret research results	Gonzalez-Martinez
	Applying research methodologies, tools, and techniques appropriately	Mitic
Teamwork/ collaboration	Teamwork/collaboration skill	Cui
	Teamwork	De Grande; Shmatko
	An ability to work as a member of a team	Manathunga
	Working constructively with colleagues, acknowledging their contribution	Mitic
Leadership	Leadership	De Grande: C Jackson; Manathunga; Shmatko
	Influencing others, providing direction, encouraging contribution	Mitic
Teaching skills	Teaching skill	Cui; De Grande; Manathunga
	Teaching competence	Haapakorpi

because kindergarten to 12th-grade education research areas tend to receive more funding than higher education teaching and learning. Universal education has a larger body of practitioners as stakeholders so this may be appropriate. Again, literature on skills required of PhDs in industry is much smaller than that on undergraduate and graduate level skills where there are greater numbers of students. In addition, conducting a meta-analysis of studies on 'industry' perceptions or 'PhD student' perceptions of course ends up ignoring considerable diversity in views.

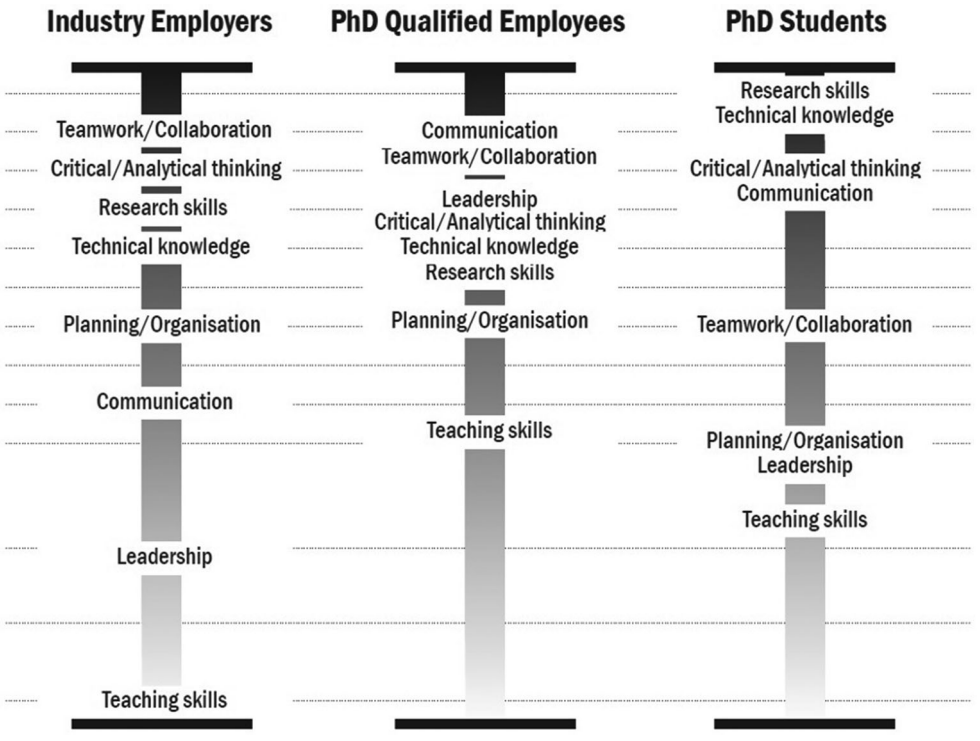

Figure 1. Skills identified by three key stakeholder groups, ranked according to frequency identified in studies and priority identified within studies. Higher ranked are ranked higher in the column.

Clearly, much more research is required to understand how different industries, different disciplinary settings, different doctoral programs do address, or should address industry needs. With our exclusion criteria in place, the resulting 11 articles are however surprisingly small considering how integral PhD student work is to the overall research output of universities. It's hard to avoid the suspicion that since students are largely trained and supervised by those on the 'inside' of academia, academic interest in what happens 'outside' that domain is limited. Regardless, there is tension over the purpose of doctoral education: should it exist only to mint new knowledge and academics, or should it be part of a broader national project of employment, technological development, and societal enhancement?

Industry may not be the preferred employment destination of PhD graduates and individual papers in this review, such as De Grande et al. (2014) confirm this, but it *is* where the majority will find employment. Therefore, understanding the broad skills requirements of industry is a priority – but not one matched by the literature. Even in the small body of work identified on employability/industry characteristics of doctoral graduates, only a minority, both in terms of studies and sample size, focused on the viewpoint of employers or PhD graduates employed in the industry. The balance of the data was what amounts to a 'convenience sample': PhD students. This study illuminates the gap between the viewpoint of PhD students – who appear to believe that research skills and technical knowledge top the rankings of requirements – and that of industry, where teamwork and collaboration are most valued.

Although employers have different priorities than employees and students, this study shows there is broad agreement on the *set* of skills necessary to make a successful transition from a PhD to industry. Despite this concordance, it is difficult to make generalisations about what institutional responses might be appropriate. Doctoral education is not a uniform experience. Beyond coursework components (largely absent, for example, in the United Kingdom and Australia), programs may be more (in the arts) or less (in programs that include laboratory work) structured depending on the characteristics of the supervisory panel or host university (Smith et al., 2006). There is a shift in Europe to generally more structured programs with industry having a larger say in curriculum (Borrell-Damian et al., 2010). Absent direct industry input, PhD supervisors (or, in the US, 'advisers') are significant in determining the scholar's progress but receive little or no training in research mentorship (Price & Money, 2002) or providing career advice (Craswell, 2007). If one takes Australia as an example, programs are funded by a scholarship for up to 3.5 years' full-time study, yet graduation rates are around 50% at the *6-year* mark (Torka, 2020). With doctoral programs attracting elite and relatively mature students, the proportions graduating on time and heading into roles their training should in theory prepare them for suggests that inside the black box all is not well.

Illuminating that unknown to some degree is Yarwood-Ross and Haigh's (2014) analysis of a harvest of all data from a global postgraduate forum, selecting all comments made about supervision or supervisors. The results offer a bleak picture of the role: the themes included communication difficulties, control/engagement, bullying, trust, and desertion. As to the content of the curriculum, individual papers included in this review offer empirical evidence that there is a mismatch between what the industry wants and what universities deliver. Kyvik and Olsen (2012), for example, found a far greater proportion of PhD graduates working in traditional university/research settings claimed to use their thesis to a 'very large degree' (73–83%) than those working outside that traditional setting (48%). The gap between the 'use' of coursework components was equally concerning (41%–45% in traditional settings to 24% elsewhere). Results from Shmatko's (2016) large sample of Russian PhD-qualified employees and the smaller Belgian sample from De Grande et al. (2014) suggest there are many skills missing, or skills enhanced in doctoral work that miss the mark in the industry. However, work with American graduates by Sinche et al. (2017) is more optimistic, particularly in relation to science disciplines.

Some scholars call for limiting PhD intakes for the sake of balancing academic workforce demand and supply (for example, Andalib et al. (2018); Cyranoski et al. (2011); and Larson et al. (2014)). Our standpoint, echoing Molla and Cuthbert (2019), Mewburn et al. (2020), and Chen et al. (2020), is that encouraging more PhDs working in non-academic sectors is beneficial, in line with OECD countries' long-term plan to move towards knowledge-based economies driven by learning, innovation, and technology. It is foreseeable PhDs' in-depth disciplinary knowledge, innovation, evidence-based decision making, critical thinking, and advanced method design capabilities will increasingly be desired beyond tertiary education.

Our findings also reveal a long-standing problem across the skills literature: the same or similar skill sets repeatedly show up in studies in the form of surface-level 'skills talks' (Hinchcliffe, 2007), with small variations, and skill rankings seem rarely consistent. In the literature we examined we saw the same complaint outlined by Hinchcliffe (2007) – a

precise definition of each skill is often absent. Precision in definitions is required before curriculum can be developed to address gaps. The conversation needs to move beyond the query of 'what' the skill items are to in-depth examination of 'how' these umbrella skill terms are operationalised.

Three overarching questions thus remain unanswered by this literature: (1) are skills required of academics the same as those required of industry researchers? (2) even if skill terms are named identically in industry and academia, do they refer to the same activities? And (3) is there any difference between industry sectors regarding the way the same skill term is operationalised?

Answering these three questions can help decide whether we need employability for 'a' job or 'the' job after all. Current doctoral employability training programs are mostly based on the transferrable skills development paradigm, but the transferability of skills has recently been challenged. For example, Chen et al's (2020) job ads analysis shows the same skills in computing and healthcare industries vary both qualitatively and quantitatively in definitions and relevant expectations due to workplace culture reasons. Employer complaints about PhD graduates' workplace performance (e.g., in Allen Consulting Group, 2010) are another indication we may need to align doctoral employability training more closely with industry cultures.

Another important finding arising from our analysis is a noticeable gap in the perception of skills importance among PhD candidates, PhD-qualified employees, and industry employers. While PhD candidates in our reviewed studies perceive research skills and technical knowledge as the most important, industry employers and PhD-qualified employees attach greater importance to teamwork and collaboration. This may be because current PhD employability training programs may fail to explicitly articulate industry expectations, with the exception of industry-linked or funded programs (Manathunga et al., 2009). Alternatively, student scholars may resist industry posts even when encouraged to embrace them (Dufty-Jones, 2018), treating industry as a 'silver medal' when in fact PhD graduates in industry may, to put it bluntly, make more (financial) gold (Dufty-Jones, 2018; Molla & Cuthbert, 2015). Despite this, this review confirms the crush of applicants for limited academic positions will continue. Academy of Management data showed year-on-year intensification of this crush: the ratio of applicants to available academic jobs increasing from 1.63 in 2017 to 6.20 just three years later (Pineault et al., 2021). The higher education sector may not be motivated, currently, to 'sell' industry as a career outcome. This may change.

We acknowledge employability training based only on teaching skills via coursework is not sufficient to produce 'industry ready' graduates, because industry work, like research itself, is often unstructured. Initiatives such as industry-university cooperation and PhD internship programs running in parallel to consolidate students' understanding of skills are likely paths forward. However, ill-defined learning outcomes in industry and internship programs have been documented as a barrier to meeting student and employer expectations (Manathunga et al., 2009; Valencia-Forrester, 2019).

Nevertheless, encouraging candidates to engage in networking with industry may improve applied knowledge production. PhD programs being encouraged to emphasise industry links improve skills development, knowledge transfer (Australian Department of Education as cited in Roberts (2018)), and non-academic career preparation (Patricio & Santos, 2019). However, with candidates' rates of publication tending to drop if

industry partners exert too heavy an influence on PhDs (Miller et al., 2013), the balance between industry and 'purer' research priorities can be easily upset. The question of where the balance lies, and who should be responsible to readjust the balance, remains.

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