The Nexus Between STEM Qualifications and Graduate Employability: Employers' Perspectives

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Abstract

A science education is an important element of a literate, advanced and modern society, and the teaching of science is mandatory through to mid-secondary schooling. Despite this, and notwithstanding the range of skills and capabilities provided by a science degree, a straight bachelor's degree (BSc) does not guarantee a science-related career. In fact, recent evidence indicates that only a moderate proportion of BSc graduates obtain science-related employment immediately upon leaving university. Reasons for this include the general nature of a science degree and the diversity of jobs possible for such graduates. A considerable gap in the literature pertaining to science graduate employability is the lack of employer perspectives on the comparative value of various tertiary qualifications (e.g. BSc, Masters, PhD). Insight into such perspectives, and the linking of this to the skill sets provided by different qualifications, may provide a basis to better inform students about their study choices and considerations regarding postgraduate study, framed against their longer-term career aspirations. This information can also enable university educators to refine science curricula to better inculcate the skills most highly valued by employers, thus providing greater leverage for students as they progress through their university studies. This paper reports on such a study, and articulates the potential synergies that may arise from strengthening the dialogue and collaboration between science educators and STEM graduate employers.

Introduction

A scientific education, one that provides a good foundation for acquiring and using all kinds of knowledge later in life, is a vital component of any developed modern society (National Academy of Sciences 2010; Harris 2012). From about the mid-twentieth century, science has been taught from primary through to mid-secondary school levels, although scientists and educators alike have called attention to the importance of studying mathematics and science across *all* years of secondary schooling (Brown 2009). Despite such calls, fewer students are studying senior secondary science, due to a combination of student attitudes to science and broader structural issues (Lyons and Quinn 2015), such as the removal of prerequisites for some university courses (Kennedy, Lyons and Quinn 2014). Consequently, this decline does not continue at the tertiary level, with substantial increases in university science enrolments observed since undergraduate places were uncapped in 2012 (Freeman 2014), broadly mirroring increases across the sector. However, completion of a straight bachelor's degree in science (BSc) is no guarantee of a science-related career. Indeed, in their paper on employment of Australian BSc graduates, Rodrigues, Tytler, Darby, Hubber, Symington, and Edwards (2007) reported that about 50% were employed in positions outside science. Reasons for this include the general nature of a BSc, and the various jobs possible for such graduates. This contrasts with the situation nearly two decades ago, when 68% of Australian science graduates reported being employed in a science-based organisation (McInnis, Hartley and Anderson 2000). This apparent decline in the employment of BSc graduates in science-related positions may relate to macrostructural changes in higher education, including the recently observed deterioration in post-graduation employment for other straight bachelor degrees (Graduate Careers Australia 2014).

Perhaps in response to the decline in the employment prospects of single degree graduates, together with a general trend towards upskilling across the education landscape, prospective undergraduates can now choose from a considerable range of post-secondary degrees and qualifications and options for additional study post-graduation. In an Australian context, along with the traditional BSc and Bachelor + Honours (BH) qualifications, a large number of double degrees (DDs) have become available (Adelman, Ewell, Gaton and Schneider 2011). Advanced qualifications, such as Bachelor + Masters (BM) or Bachelor + Masters + PhD (BMP), have been the traditional path towards a more academically-oriented career (Carron 2013). Although the knowledge, understanding and skills sets conferred by these various qualifications are provided by universities through published synopses, there is little to validate their accuracy or importance to prospective employers.

The plethora of tertiary qualifications currently offered, together with a tendency for many students to continue with advanced degrees following their bachelor's degree, has led some writers to warn that such students may be becoming overqualified for some positions (Green and Zhu 2010; Quintini 2011). In contrast, the increasing popularity of DDs, which encompass a broader range of studies, is thought to reflect their greater value to graduates' employability (Russell, Dolnicar, and Ayoub 2008), due in part to the broader graduate skill sets they are considered to deliver (Fleming et al. 2010). The greater demand for DDs is reflected in their comparatively higher tertiary entrance rankings (Klebes-Pelissier 2007). One Australian university that does not offer DDs is the University of Melbourne, which introduced its 'Melbourne Model' in 2008 (Fearn 2009; University of Melbourne 2006). This model, structured as a BM, is based loosely on the European Bologna Model of tertiary study (Keeling 2006). The University of Melbourne claims that among other things, this broader educational structure produces more knowledgeable and skilled graduates compared to straight bachelor degrees (Potts 2012), which would theoretically increase employability.

Given the interrelated range of factors currently impacting graduate employment (such as career readiness, qualification type and university standing), it is timely to consider how to best align student learning, skills development and employability. In this context, employability is here defined as a graduate's discernment, acquisition, adaptation and enhancement of skills and attributes that increase their likelihood of employment (Oliver 2015). Knowledge of employer perspectives regarding the value of tertiary qualifications, and the linking of such knowledge with the skills and attributes provided by various qualifications, may provide a basis to better inform students about their study choices and longer term career aspirations. This is of particular relevance to postgraduate degrees, in terms of the relative costs and benefits associated with such study. This information may also be useful to university educators, to refine STEM (science, technology, engineering and mathematics) curricula in order to better inculcate the knowledge and skills most highly valued by employers, thus providing greater leverage for undergraduates as they progress through their studies. This paper reports on such a study and explores the potential synergies arising from strengthening the collaboration and dialogue between STEM educators and employers of their graduates across the qualification spectrum.

Methods

Employer perspectives

The study survey tool sought employer perspectives on two linked elements of employability; qualifications, and skills / attributes. The survey methodology used was as described by Rayner and Papakonstantinou (2015), and administered under Monash University Human Research Ethics approval # CF14/1703–2014000840. The volunteer-response survey was emailed to 302 Australian STEM employers (predominantly Melbourne-based) of whom 116 provided specific responses about science qualifications. Employers were invited to rank five tertiary science qualifications (BSc, BH, DD, BM and BMP), on a scale of one (least important) to five (most important). For attributes and skills, employers ranked ten of these, grouped according to type: vocational, generic and interpersonal (see Table 2 for individual descriptions of each attribute / skill). Ranking was on a scale of one (least important) to ten (most important).

In order to investigate possible differences among qualification rankings based on STEM sub-disciplines, employer responses were grouped according to their sub-discipline area with ranking means then calculated for each qualification, with significant differences indicated (Table 1). Respondents were human resources managers or equivalent for each STEM employer. No inducements or incentives were offered to respondents, all of whom had a direct role in hiring STEM graduates.

Information regarding the skills and attributes specific to each of the five tertiary science qualifications in this study was obtained from publically available handbook entry websites, for fourteen Australian universities. These were the Australian National University, Deakin University, Federation University, La Trobe University, Monash University, RMIT University, Swinburne University of Technology, University of Adelaide, University of Melbourne, University of Queensland, University of Sydney, University of Western Australia, and Victoria University. Handbook entries for each qualification were accessed and collated and the text analysed and coded, using a grounded theory approach (Flick 2006), for the frequency and co-occurrence of each of the surveyed skills and/or attributes (Table 2).

Results

Employer ranking of science degree qualifications

Overall, STEM employers ranked the BH and BM qualifications equally highly (‘a’, in Figure 1), and each significantly higher than the BMP ($t = 1.57$, $p = 0.0009$; $t = 1.03$, $p = 0.02$ respectively). The BH was also ranked significantly higher than the DD ($t = 0.97$, $p = 0.03$). All qualifications ranked more highly than the straight BSc (t values between 1.9 and 6.4, with corresponding p values < 0.001) (Figure 1). When individual responses are examined, the BMP received the highest number of top (‘5’) rankings from surveyed employers (38.5%), followed by the DD (23.1%), BH (18.5%), BSc (10.8%), and BM (9.2%). The difference between these results suggests a possible bimodal pattern of ranking along the qualification scale, from lowest (BSc) to highest (BMP).

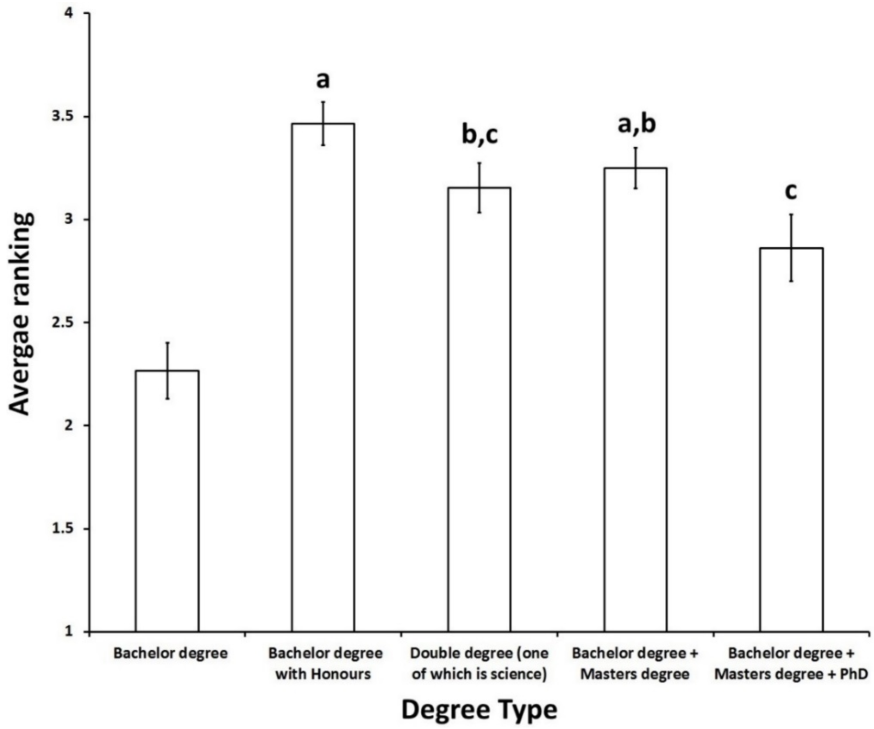

Figure 1. Employer rankings (means +/- SEM) of the importance of science degree qualifications (BSc, BH, DD, BM and BMP). Shared alphabet letters denote non-significant differences between means (n=116).

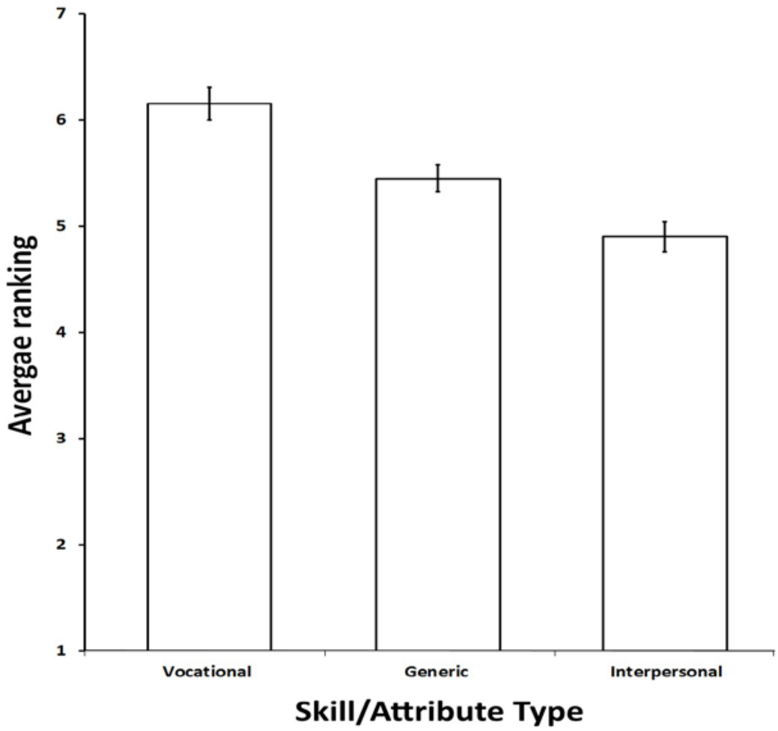

Figure 2. Employer rankings (means +/- SEM) of graduate attributes/skill sets, grouped by type (n > 348 for each, as some employers did not rank specific skills / attributes).

Investigating STEM employer sub-discipline rankings of qualifications

Comparing sub-disciplines, the BH qualification was ranked significantly higher than the BMP for six of the different employer groups: Biological research (t =1.14, p = 0.014), Chemical manufacturing (t = 0.90, p = 0.045), Chemical R&D (t = 1.79, p = 0.002), Engineering consulting (t = 1.03, p = 0.03), Geosciences research (t = 1.06, p = 0.04), and Water research (t = 0.99, p = 0.045) (Table 1). In contrast to this broader pattern, two employer groups ranked the BM and BMP higher than all other qualifications. These were Medical research (t-values between 0.9 and 2.3, with corresponding p-values < 0.04) and Scientific instrumentation (t-values between 1.8 and 3.2, with corresponding p-values < 0.01) (Table 1).

Connecting science degree qualifications and graduate attributes: Employer perspectives

Some STEM employers (approximately 10% of total respondents) made a number of comments about the relationship between qualifications and graduate skills sets. For example, an organic chemistry employer commented that:

"Honour's graduates have a much higher lab skill set and these are the people we would hire."

and

"Recent graduates seem to have an inflated sense of entitlement and do not realise that a degree gets them a job, but then they still have to learn how to work as a scientist."

Table 1. Employers grouped by STEM sub-discipline, specifying qualifications that ranked significantly higher with respect to one another. NSD denotes no significant differences among qualification rankings per employer sub-discipline group. All *p* values < 0.05.

Employer sub-discipline area	Respondents (N)	Qualifications
Biological research	27	BH > BM > BMP = DD > BSc
Biotechnology	7	BH, DD, BM and BMP > BSc
Chemical manufacturing	7	BH > BMP
Chemical R&D	8	BH = BSc = DD > BM = BMP
Engineering	4	BM > BSc
Engineering consulting	7	BSc, BH, DD and BM > BMP
Engineering R&D	4	BH, DD > BSc
Geosciences research	4	BH > BMP
Medical research	18	BMP > all but BM
Physics research	3	BH > BM
Scientific instrumentation	3	BMP, BM > all others
Water research	4	BH, DD, BM > BMP
Analytical services	4	NSD
Climate science	3	NSD
Mining services	3	NSD
Pharmaceutical science	5	NSD
Scientific communication	1	NSD
Statistics	3	NSD
Transport research	1	NSD

With respect to the increased number of science graduates and the need for them to upskill beyond the BSc degree, four different employers commented that:

"University degrees tend to 'pigeon-hole' studies into their retrospective field instead of broadening capabilities knowledge."
"*...the level of competition for positions requires a graduate student to stand out, not to just expect they will/deserve to get their perfect dream job straight out of University*."
"*...graduates require a minimum of Honours to demonstrate their capacity for research. Our current intake includes 2 x Monash graduates (1 with Honours and 1 with Masters).*"
"*I have found that while I have had a number of volunteers that want to be marine biologists, there are very few who will go above and beyond the normal activities of an undergraduate student to make it happen.*"

Connecting graduate skills and attributes with tertiary science qualifications
Vocational attributes were listed a total of 90 times in the university handbook entries for the five science qualifications (Table 2). When qualifications were grouped, 'discipline knowledge' was stated most often (37), followed by the 'ability to develop relevant knowledge' (28), and the 'ability to apply relevant knowledge' (25). Similarly, generic attributes were listed 88 times in university handbook entries for these qualifications (Table 2). Of those in the generic grouping, 'communication skills' were stated most often (34), followed by 'critical thinking' (29), and then 'problem-solving' (21) and 'numeracy' (15). Interpersonal attributes were listed 37 times for these qualifications (Table 2). 'Teamwork' was stated most often (15), followed by 'understanding of ethical conduct' (14), with 'flexibility / adaptability' mentioned least often (8).

Table 2. Classification of graduate attributes and skills, and the frequency of each for fourteen Australian university handbook entries per qualification type (number of times stated in a qualification handbook entry: maximum per attribute / skill = 14)

Type	Attribute / skill	BSc	BH	DD	BM	BMP
Vocational	Ability to apply relevant knowledge	5	6	4	4	6
Vocational	Ability to develop relevant knowledge	4	9	3	5	7
Vocational	Discipline knowledge	5	9	6	7	10
	Subtotal	**14**	**24**	**13**	**16**	**23**
Generic	Critical thinking	4	8	4	6	7
Generic	Oral and written communication	6	9	5	7	7
Generic	Problem-solving	6	5	5	2	3
Generic	Numeracy / Quantitative / Statistical	2	3	3	3	3
	Subtotal	**18**	**25**	**17**	**18**	**20**
Interpersonal	Flexibility / adaptability	3	1	2	1	1
Interpersonal	Ability to work in teams	4	4	5	1	1
Interpersonal	Understanding of ethical conduct	3	6	2	1	2
	Subtotal	**10**	**11**	**9**	**3**	**4**
	Total	**42**	**60**	**39**	**35**	**47**

When the attributes are grouped according to type, qualification statements emphasise vocational and generic skills and attributes far more often than interpersonal ones. This is somewhat consistent with employer rankings of these grouped skills and attributes (Figure 2), but not uniformly (vocational > generic > interpersonal).

Discussion

Our study has shown that first and foremost, surveyed STEM employers place considerable value upon vocational skills, such as an ability to (i) apply knowledge and (ii) develop knowledge relevant to the position. The acquisition of discipline-related knowledge has previously been shown to provide a strong basis for employment, and a necessary foundation from which other skills can be developed or enhanced (Toner 2010). These findings are consistent with what has been previously reported for vocational-related skills (Heijke, Meng and Ris 2003), despite the widespread and long held belief among some U.K. academics that generic skills are paramount (Leckey and McGuigan 1997).

That Australian STEM-related employers consider the BSc to be a lesser qualification compared to the others is consistent with Coates and Edwards (2009), who undertook an in-depth analysis of graduate employment status five years post completion of bachelor degrees at an Australian university. However, further information is required about the fundamental characteristics of the BSc that make it the lowest ranked of the qualifications. The BH and BM both require higher levels of knowledge development, involving elements of design and application (Adelman et al. 2011), than the BSc, which should have considerable appeal to employers. It is also possible for BH and BM students to have industry co-supervisors on embedded, applied research projects, which might serve to enhance their employment prospects post-graduation (Duggan 2008). Where once an extra degree was rare, the massification of higher education now generates many more graduates, which considerably diminishes the value of a straight bachelor's degree (Guri-Rosenblit, Šebková and Teichler 2007). Employers can thus be much more selective, and employ graduates with additional qualifications, such as science-engineering double degrees (Fleming et al. 2010).

The very low number of employer top rankings for the BM is disquieting, given its promotion by universities that have implemented the Melbourne model (Hil 2015). That the BM qualification ranked co-highest overall reinforces the notion of a bimodal pattern of responses among employers. Conversely, the high number of top rankings for the BMP is curious, given that this qualification was ranked second lowest overall; this again suggests a bimodal pattern of responses among employers. Together, these conflicting results for the BM and BMP call for further study and the collection of more robust data. At the high ranking end, there appear to be subgroups of employers (Medical research, Scientific instrumentation) that consider BMP graduates to be more independent and possess high level skills in designing and conducting research, and analysing their findings. This view has been previously expressed by both industry (Harman 2004) and academia (Pearson 2005), and indeed, independence is one of the key attributes attained during a doctorate, based on the majority of university handbook entries evaluated for this qualification. Nevertheless, the difference in independence generated through each of a BMP or BH may be less pronounced than indicated by university handbook entries, at least in terms of a graduate's capacity for independence in the workplace rather than as an autonomous scholar, the archetype of the BMP pathway (Tennant 2004).

The apparent lack of alignment between Australian universities and STEM employers on *the* most important types of skills or attributes may reflect the respective priorities of these two groups. Universities appear to focus on knowledge transfer and development of associated vocational skills and attributes (Boulton and Lucas 2011), along with development of generic skills. Employers, on the other hand, tend to prioritise the need for vocationally-related skills over generic and interpersonal ones. These conclusions are based on the somewhat arbitrary classification of these skills, and we recognise that there is a degree of overlap between them and their respective groupings. For example, the ability to apply relevant knowledge, which ranks so highly among employers, incorporates elements of critical thinking and problem solving emphasised by universities. In order to better understand employer perceptions of these attributes and skills, further qualitative research is required, perhaps through semi-structured interviews with selected respondents. Two further caveats to our findings are (i) the relatively low number of universities we evaluated, and (ii) university science qualifications statements are essentially marketing tools, with a tendency to be all-embracing regarding their educational value to students.

It is perhaps unsurprising that some surveyed employer groups ranked the BMP significantly lower than the BH and BM qualifications. Although a doctorate has traditionally provided the basis for academia, it is now no guarantee of such a career (Parada and Peacock 2015). The flow on effect of these changes may be a declining interest in an academic career among PhD graduates (Edwards and Smith 2010). Compounding this is the perception that PhD graduates lack some of most highly valued employability skills (Mowbray and Halse 2010), which in the STEM disciplines include flexibility and adaptability (Rayner and Papakonstantinou 2015). More recently, such skills have been included in the considerable list of attributes being promulgated in the push to enhance the employment prospects of PhD graduates, both in Australia (Harman 2004) and in other developed economies (United Kingdom 2001; Carron 2013). In response to this, many universities have implemented postgraduate programs such as the one at Monash University (2015). It is possible that given the recent nature of their introduction, the benefits of such programs for the employability of doctoral students are yet to be fully realised. In time, and if successful, such programs may have concomitant positive impacts on employer perspectives of the value of a doctorate.

It may be that the lower value placed on the BMP is an artefact of the employers surveyed in this study. Doubtless, university academics would have a very different perspective on the value of the BMP. However, some science PhD graduates appear to place low importance on the value of their qualification in preparing them for employment (Manathunga, Pitt and Critchley 2009), which is at odds with relatively robust employment rates, at least for male BMP graduates (Evans 2007). The apparent discord between such rates of employment and employer rankings of the BMP point to a need for more information about PhD graduate destinations, particularly in terms of their destination industries. Nevertheless, it is possible that students who complete a BMP will not only have relinquished the opportunity for a salary over the time taken to acquire these qualifications, but also be saddled with substantial financial debt. This, together with the diminished likelihood of an academic position (May, Peetz, and Strachan 2013) following a BMP, might ultimately contribute to decrease its future appeal as a pathway.

The outcomes of this study, together with an increasing body of research on graduate employability, casts something of a shadow over the value of the PhD as the most highly prized academic qualification, at least for a broad range of less-specialised careers. This is because Australian doctoral graduates are squeezed on one side by a lack of tenured academic positions, and on the other by an apparent disinterest among employers in the value of this qualification to their particular enterprise. The bigger questions of what this means for the future of doctorates, and in the quality of students undertaking them, will be answered in time. Nonetheless, the basis of a university's ranking and associated reputation, on such measures as research output and competitive grant income, suggests that the doctoral apprenticeship model is unlikely to change in the foreseeable future.

Conclusions and further research

In an age in which STEM graduates are becoming on the one hand, ever more qualified, but on the other increasingly employed in areas outside their discipline major, it is extremely important that they understand which qualifications are likely to optimise their likelihood of employment post-graduation. In this study, Australian STEM-related employers ranked vocational skills and attributes significantly higher than generic and interpersonal ones. Of the five assessed tertiary science qualifications, STEM employers preferred the BH and BM. In addition, we have identified which qualifications are preferred by probing the various sub-discipline areas of surveyed STEM employers, yielding insights about their preference for the BH over the BMP. Analysis of university synopses of the various types of graduate skills and attributes has indicated that interpersonal ones are least mentioned, compared to vocational and generic ones. Finally, there is a considerable need to more frequently monitor STEM employer perceptions of the value of various qualifications and associated graduate attributes, and keep both undergraduate and postgraduate students abreast of these outcomes, so as to increase their prospects of post-university employment in STEM-related industries.

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Appendix 1. Australian STEM employer survey

Faculty of Science, Monash University - Employer Survey
Background and rationale

The Faculty of Science, Monash University, is undertaking a survey of past, present and potential employers of STEM graduates. This is being done to enhance and/or establish strategic institution-industry partnerships, and to better understand employer views on the importance of a science degree and the skill levels and attributes of STEM graduates. Looking to the future, we also wish to ascertain how our curricula and degree structures can enhance graduate skills and attributes. We appreciate your cooperation with this survey and strongly value your feedback.

Your organisation: ____________________________________

Organisation sub-discipline area (e.g. 'biotech' / 'medical research') _________________________

Number of employees: _____________

Please use the following scale to rate your response to the below statements, considering the (a) current situation and (b) situation in ten years.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Rating	1	2	3	4	5

Attribute category	**An important graduate attribute is / will be**	**Current situation**	**Situation in 10 years**
Vocational	● discipline or content knowledge in a major field of study.		
Vocational	● the ability to apply knowledge relevant to the field / discipline.		
Vocational	● the ability to develop knowledge relevant to the position.		
Generic	● written communication skills.		
Generic	● oral communication skills.		
Generic	● the ability to problem-solve.		
Generic	● the ability to think critically.		
Generic	● numerical / statistical / quantitative skills.		
Interpersonal	● the ability to work effectively in teams / cooperatively.		
Interpersonal	● an understanding of ethical conduct.		
Interpersonal	● a capacity for flexibility or adaptability.		
Interpersonal	● self-confidence and independence.		
Interpersonal	● personal planning and organisational skills.		

What skills or attributes (if any) do you think are <u>lacking</u> in Monash science graduates?

In what ways does Monash <u>best</u> prepare its graduates for employment in your organisation?

In what ways could Monash <u>better prepare</u> its graduates for employment in your organisation?

Please rank the following graduate attributes from 10 (most <u>important</u>) to 1 (l<u>east important</u>).

- Discipline or content knowledge in a major area ___
- Ability to apply knowledge relevant to the field / discipline ___
- Ability to develop knowledge relevant to the position ___
- Communication skills (oral, written) ___
- Problem solving abilities ___
- Critical thinking abilities ___
- Numerical / statistical / quantitative skills ___
- Ability to work in teams / groups / collaboratively ___
- Understanding of ethical conduct ___
- Capacity for flexibility / adaptability ___

In evaluating students for a position in your organisation, all other things being equal, rank your choice (1-5, with 5 being your top choice) of applicant on the basis of their degree qualification.

- Bachelors degree ___
- Bachelors degree with Honours ___
- Double degree (one of which is science e.g. Science / Engineering) ___
- Bachelor degree + Masters degree ___
- Bachelor degree + Masters degree + PhD ___