Comparing STEM Students' and Employers' Emphases on Career Information Literacy- A Study on Undergraduate Capstone Units

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Abstract

The mixed graduate employment outcomes of Science, Technology, Engineering and Mathematics (STEM) have often been discussed in terms of social-economic factors, which are largely beyond educational institutions' control. This study aims to examine an endogenous factor related to perceptions of career and employability development to inform course designs and facilitation. Building on a previous study, we examine STEM career information literacy learning emphases in generic, discipline-based and transformative learning. Specifically, we identify and describe the variance (a) between STEM student cohorts and (b) between STEM students and employers.

In this nonexperimental, cross-sectional study, we collected responses via a career information literacy learning questionnaire, from final year STEM capstone unit students and their potential employers in an Australian university. The findings indicate that, overall, STEM student cohorts do not differ from each other in their emphases on different attributes of career information literacy, except for the Mathematics, Statistics, Physics and Astronomy cohort. However, when combined and analysed as a group, the STEM students exhibit significantly different career information literacy focuses from STEM employers. The results point to a critical need for STEM students to be educated about employer perceptions. Further implications and limitations of the study are discussed.

Background

In spite of the strong demand for STEM skills, STEM disciplines have yielded varying graduate outcomes, with different levels of employment, unemployment and underemployment (Norton and Cakitaki, 2016; Office of the Chief Scientist, 2012). Past studies have examined the heterogeneity of STEM graduate outcomes from multiple aspects to explain the uneven employment outcomes that STEM graduates experience. These have included social-economic factors, such as labour market conditions and fields of work (Xue and Larsen, 2015), perceived value of qualifications (Rayner & Papakonstantinou, 2016), occupation relevance to major (Xu, 2013), as well as gender (Broadley, 2015; Riegle-Crumb, Moore, & Ramos-Wada, 2010) and race (Riegle-Crumb et al., 2010).

Whilst these external socio-economic factors influencing STEM graduate outcomes are important, educators seek knowledge of pedagogical value to enable them to shape and improve graduate career outcomes. Some have examined the match between graduates and the workforce by detecting gaps in required skills, attributes, and work-readiness of STEM graduates (Durrani &Tariq, 2012; O'Byrne, Mendez, Sharma, Kirkup, & Scott, 2008; Prinsley & Baranyai, 2015; Sarkar, Overton, Thompson, & Rayner, 2016). The others further indicated issues with lack of information for decision making (Alexandre, Portela, & Sá, 2010), students' self-perception (Bennett & Male, 2017), and lack of cultural diversity in the study body (Daily & Eugene, 2013). Identifying relevant endogenous factors may point to a way to influence learner perceptions and motivations as well as align students' and employers' interests and focuses.

It is in this context that we seek to understand STEM students' career development focuses, which presents an opportunity to effectively integrate university learning with personal aspirations. After all, it is problematic to think of STEM students as passive carriers of knowledge or simply sums of skills upon entering the workforce. Without understanding students' and employers' emphases on career development, our knowledge of student-employer fit cannot be complete. Therefore, in embedding employability in higher education, knowing how STEM students and employers view and value career development is of pedagogical importance.

Career development learning is a broad topic encompassing concepts such as career planning, indecision, identify development, career adaptability, and career management skills (Bridgestock, 2009; Stringer, Kerpelman, & Skorikov, 2011). Whilst we acknowledge the usefulness of general career development concepts, for the purpose of this study, to maintain a focus on and direct reference to disciplines, we examine the importance ascribed to aspects of career development in three university education contexts- generic, discipline-based, and transformative learning.

The approach of examining career development within cross-discipline, discipline-specific, and trans-discipline contexts was reported in a previous study of Career Information Literacy (CIL) (Lin-Stephens, Manuguerra, Downes, Dawes, Kennett, & Uesi, 2017). The CIL approach integrates career development learning (Watts, 2006) with generic, situated and transformative information literacy (Lupton, 2008). It classified career development learning in cross-discipline, discipline-specific, and trans-discipline domains of knowledge and ability and produced 12 attributes of career information literacy. We simplified the original framework for the purpose of this study. Table 1 outlines the adaptation for brevity and direct reference to career development and university learning in generic, discipline-based and transformative contexts.

Table 1: Twelve career information literacy attributes based on career development learning in three university learning contexts

University learning	***Career Development Learning***			
	Self awareness	Opportunity awareness	Decision making	Transition learning
Generic	General personal profile (interests, attributes, etc.)	Knowledge of broad career options	Ability to evaluate career choices	Practical skills in securing work and handling applications
Discipline-based	Discipline knowledge and skill base	Knowledge of degree-related work opportunities and requirements	Ability to target degree related work	Ability to show how one can add value to an employer from discipline backgrounds
Transformative	Critical thinking in career transitions	Ability to contribute to any work in a meaningful way	Outside of the box thinking in career decisions	Ability to challenge oneself and adapt to changing environments

Aims

Identify intra-cohort differences in career information literacy between STEM student cohorts

It is unknown that, under the broad STEM umbrella, if students from different disciplines share the same perceptions of career development related to their disciplines. Therefore, our first aim is to gather data on STEM students' career information literacy focuses and detect variance amongst cohorts. Different STEM student cohorts may exhibit different attitudes towards career development, place varying emphases on employability, or possess unique needs in learning about the world of work. Variance in focus may influence different cohorts' career preparation and employment outcomes. It also has implications for educators to facilitate career development learning with different cohorts. Hence, we ask the first research question in this study- Do STEM student cohorts differ from each other in their focus on career information literacy development?

Identify inter-cohort differences in career information literacy between STEM students and employers

Next, equally, given the lack of existing information on what STEM employers value in students' learning for career development purposes, we aim to collect employer data and compare career information literacy emphases between STEM students and employers. Identifying differences between STEM students and employers is essential for universities to act towards an effective alignment between student preparation and talent acquisition. Therefore, we pose the second question- Do STEM student cohorts differ from STEM employers in their focus on career information literacy development?

Method

A nonexperimental, cross-sectional study is designed to students' and employers' emphases on career information literacy learning. The study is approved by Macquarie University Human Research Ethics Committee (Reference number 5201500815). As part of the study, this data collection took place over two semesters in 2016 and 2017.

One career information literacy questionnaire for students and one for employers were designed and used to gather data on attributes of career development learning valued by students and employers respectively (Appendix 1). The questionnaire contains 12 items on a 5-point Likert scale ranging from strongly disagree, disagree, neutral, agree, to strongly agree for students and employers to assess the respondents' focus on career and employability development. The 12 items denote attributes of career information literacy within three university learning contexts listed in Table 1.

Data collection

A paper-based questionnaire containing the 12 CIL items for students was administered in the 34 final year capstone units in a STEM faculty in an Australian university. Data collection occurred at the end of two semesters, primarily face to face. A web survey link was provided to students who could not attend classes in person. The recruitment of participants was limited to capstone unit students, given that compared with students in other stages of their studies, capstone students were more likely to have already done some career reflection. Participation was voluntary. Of the 1176 students who were enrolled in the capstone units, 517 provided valid responses, giving a response rate of 44%.

In the same period, a separate paper-based questionnaire for employers was administered to employers who approached this STEM faculty to engage students in recruitment and employability activities, such as careers fairs, employer presentations, guest lectures, etc., to attract students to work in relevant STEM opportunities. The employers were identified primarily by the University's Career and Employment Service and invited to participate. Of the 80 employers involved in these student-industry engagement activities and invited to participate in the study, 62 responded to the questionnaire, giving a response rate of 78%.

Data were entered by research assistants who worked in pairs. One person read out the responses for the other to enter them into the data management system. The research assistant who read the responses also monitored the screen to check that responses were entered into the system correctly.

Data analysis

There are ten academic departments within the STEM Faculty we studied. We grouped closely related disciplines together in our analyses for several reasons. For one, the grouping provided a larger sample size for each unit of analysis (in the case a cohort) than analysing each single discipline as an individual group separately. For another, students from closely related disciplines are likely to have studied together in various stages of their programs. Still another reason, and of most relevance to industry stakeholders, is that employers are usually not bounded by strict degree name groupings and recruit from closely related disciplines.

Therefore, data from closely related disciplines were analysed as five distinct cohorts (a) Mathematics, Statistics, Physics and Astronomy (MSPA), (b) Engineering and Computing (ENG/COM), (c) Environmental and Earth Planetary Sciences (ENV/EPS), (d) Biological, Chemical and Biomolecular Sciences (BIO/CBM), and (e) Chiropractic (CHIR).

Standard ordinal regression was used to study the effect of a range of covariates on the career development focus. These included career information literacy attributes, discipline and other covariates, namely, age, sex, residency, recent activities, work history and future plan.

Results

STEM student cohort responses

We summarised characteristics of the STEM discipline cohorts in Table 2 and noted statistically significant differences of cohorts from the STEM overall group in key aspects. Students from most disciplines shared similar demographic and activity-based characteristics. Age composition was similar across all cohorts. Gender imbalance in science and engineering disciplines in general was well-known and reflected in this sample. Compared with the overall STEM gender ratio in this faculty, the engineering and computing cohort had the highest male to female ration, while the biology, chemical and biomolecular sciences cohort had most significant presence of female students.

Table 2: Capstone student respondents' characteristics

Capstone units	MSPA	ENG/COM	ENV/EPS	BIO/CBM	CHIR	STEM
Responses	80	186	60	145	46	517
Enrolments	110	350	190	448	78	1176
Response rate	73%	53%	32%	32%	59%	44%
Sex		*		*		
Male	60%	86%	57%	48%	67%	67%
Female	38%	13%	43%	51%	30%	32%
Age						
19 or under	0%	1%	2%	0%	0%	0%
20-25	84%	85%	75%	77%	76%	81%
26-30	11%	8%	5%	14%	11%	10%
31-40	5%	4%	12%	6%	9%	6%
41+	0%	2%	7%	3%	4%	3%
Activities in the past 12 months					*	
Part time work	79%	62%	78%	89%	74%	75%
Job search	35%	53%	60%	59%	15%	49%
Student groups/societies	25%	24%	37%	30%	22%	28%
Unpaid work experience	18%	22%	43%	37%	7%	28%
Volunteer or community work	28%	22%	40%	45%	15%	30%
Project work involving external clients	34%	22%	47%	13%	3%	21%
Full-time work	10%	17%	13%	8%	2%	11%
Professional association involvement & networks	3%	9%	12%	11%	0%	8%
Overseas exchanges or studies	4%	7%	12%	4%	0%	6%
Work History						
Average total paid work history	4y	3y3m*	5y10m	5y3m*	3y5m	4y2m
Average total unpaid work history	9m	6m	11m	1y1m	6m	10m
Plan within 1 year of completing degree		*		*	*	
Work	76%	87%	67%	63%	54%	73%
Further study	33%	19%	38%	56%	57%	37%
Other	5%	9%	18%	14%	0%	10%

*p <0.05

We should point out here that the chiropractic students in this sample had a distinctively different program of study from other STEM peers. To qualify as registered chiropractors, chiropractic students had to complete two more years' training program at the master's level. Therefore, the chiropractic capstone students were not technically at the end of their training. This may explain their significantly different responses to future plans. Also, they had significant numbers of practical hours since the early stage of their degree, which was not a common feature of other disciplines' programs of study. This may explain why they were involved in less extra-curricular activities.

In analysing student responses, we found the Cronbach alpha value for the cohorts ranged from .82 to 0.9, providing confidence in the internal consistency of the 12 career information literacy attributes in both aspects of career development learning and university learning contexts.

Next, the generic, transition attribute of career information literacy was selected as a base-line reference. This was based on consultations with STEM academics in these capstone courses, who believed that generic, transition career learning was the most important attribute to foster in the final stages of the programs of study.

Standard ordinal regression showed that only CIL attributes and discipline had an effect on the CIL focus, and no interaction between the two has been found significant (Table 3). Individual effects have been modelled with random effects. To satisfy the assumption of proportional odds, student responses were collapsed into three categories: negative (disagree and strongly disagree), neutral, and positive (agree and strongly agree).

Table 3: Standard ordinal regression of STEM student responses

Coefficients		Estimate	Std. Error	Z value	P-value
Generic learning	Self-awareness	1.982	0.255	7.771	7.77e-15 ***
	Opportunity awareness	-0.127	0.178	-0.716	0.4742
	Decision making	-0.079	0.179	-0.443	0.6576
	Transition learning	(reference)-	-	-	-
Discipline-specific learning	Self-awareness	1.618	0.234	6.929	4.24e-12 ***
	Opportunity awareness	0.945	0.205	4.607	4.09e-06 ***
	Decision making	0.604	0.195	3.102	0.0019 **
	Transition learning	0.751	0.198	3.787	0.0002 ***
Transformative learning	Self-awareness	-0.104	0.178	-0.583	0.5596
	Opportunity awareness	0.597	0.193	3.091	0.0020 **
	Decision making	-0.290	0.175	-1.656	0.0978
	Transition learning	0.362	0.188	1.929	0.0538
MSPA		-0.880	0.356	-2.474	0.0134 *
ENG/COM		-0.238	0.317	-0.750	0.4531
ENV/EPS (reference)		-	-	-	-
BIO/CBM		-0.058	0.328	-0.176	0.8603
CHIR		0.591	0.436	1.355	0.1756

Random effects: Variance 2.963, Std. Dev. 1.721
Significance: ≤0.001: '***'; (0.001-0.01]: '**', (0.01-0.05]: '*'

Likewise, to compare variance between different discipline cohorts, a reference group was selected. We decided on the Environmental Sciences and Earth Planetary Sciences (ENV/EPS) group as the base line reference because of its mid-positioning on the spectrum between life science and numerical science across the five discipline clusters.

In the standard ordinal regression analyses (Table 3), the mathematics, statistics, physics, and astronomy group was the only cohort which differed from the STEM group, as the students rated every items measured significantly lower.

From Table 3, we can see that the STEM students highly valued their discipline-based knowledge and skills, degree-related work opportunities and industry requirements, ability to target specific work related to their personal profile and degrees, and the ability to show how one can add value to an employer based on what they study. These are all attributes of discipline-based career information literacies. Students also viewed their general self-understanding, and the ability to contribute to any work in a meaningful way as important to their next phase transition. Career interventions aiming to explore self and meaningful work may be designed meet these students' developmental objectives. No CIL attribute was found to be perceived by students as less important than the reference of generic transition career information literacy.

STEM employer responses

In Table 4, we present STEM employer participants' characteristics. Most employer respondents are from the private sector, working for large, small and medium enterprises (87%).

Table 4: STEM employer respondents' characteristics

n=62, response rate 78%	Frequency	Percentage
Organisation type		
Large enterprise (200+)	28	45%
Small/Medium Enterprise (< 200)	25	40%
Government	5	8%
Not for profit	4	6%
Male	24	39%
Female	38	61%
Average experience in workforce	13y3m	
Average experience in hiring	7y5m	

We examined the effect of sex, work and hiring experience on CIL focus and found no effects in the employer sample. Due to the relatively fewer responses from government and not for profit organisations, and to satisfy the assumption of proportional odds, organisation types were reduced to three categories: large enterprise, small and medium enterprise, and government/not for profit.

We kept the same generic, transition career development learning focus as the reference to be consistent with the student analysis above. Table 5 shows the results from standard ordinal regression.

Table 5: Standard ordinal regression of STEM employer responses

Coefficients		Estimate	Std. Error	Z value	P-value
Generic learning	Self-awareness	0.795	0.342	2.322	0.0202 *
	Opportunity awareness	-1.662	0.349	-4.766	1.88e-06 ***
	Decision making	-1.439	0.342	-4.212	2.53e-05 ***
	Transition learning	(reference)-	-	-	-
Discipline-specific learning	Self-awareness	0.038	0.338	0.113	0.9099
	Opportunity awareness	-1.125	0.345	-3.257	0.0011 **
	Decision making	-0.599	0.344	-1.739	0.0820
	Transition learning	1.310	0.358	3.663	0.0002 ***
Transformative learning	Self-awareness	-0.090	0.345	-0.262	0.7935
	Opportunity awareness	1.362	0.352	3.870	0.0001 ***
	Decision making	1.002	0.357	2.807	0.0050 **
	Transition learning	1.523	0.365	4.173	3.00e-05 ***
Large enterprise (reference)		-	-	-	-
Small and medium enterprise		-0.425	0.157	-2.716	0.0066 **
Government/Not for profit		-0.641	0.213	-3.009	0.0026 **

Significance: ≤0.001: ‘***’; (0.001-0.01]: ‘**’, (0.01-0.05]: ‘*’

We found that employers valued self-awareness in generic learning, transition learning in discipline-based learning, and all but one career development focus in transformative learning. Employers had significantly high focus on motivation and ability to contribute to any work in a meaningful way, ability to think outside of the box in career decision making, and ability to challenge one’s existing practices and take critical actions to adapt to changing environments. These were predominantly transformative attributes of career information literacy.

With the highest number of respondents, large enterprise was selected as the reference group for the ordinal regression. We found that organisation type had significant effects on career development focuses, with large enterprises rate items measured significantly higher than small and medium enterprises and government and not for profit organisations (Table 5).

Discussion

Comparing STEM student cohorts’ career information literacy focus

To our first research questions- do the various STEM student cohorts differ from each other in their focus on career development, the answer is not really. Figure 1 shows that the mathematics, statistics, physics and astronomy group are the only group which differs significantly from the base line, with 95% confidence interval.

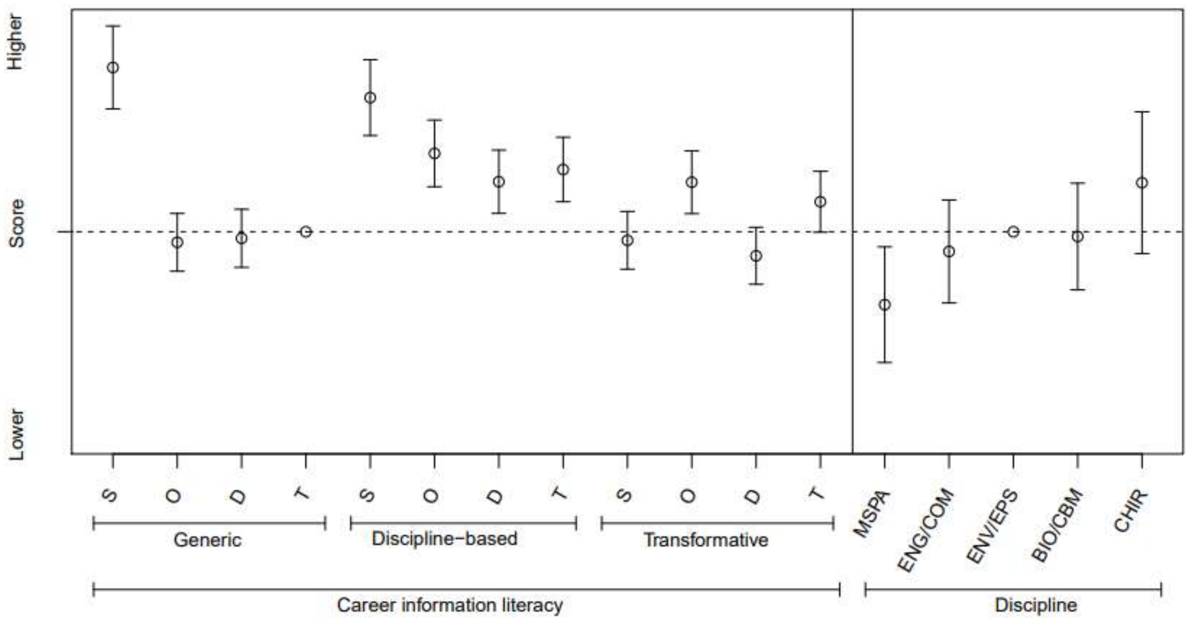

Figure 1: Career information literacy focus by cohort- undergraduate STEM capstone course students
S: self-awareness; O: opportunity awareness; D: decision making; T: transition learning
MSPA: mathematics, statistics, physics, astronomy
ENG/COM: engineering, computing
ENV/EPS: environmental sciences, earth and planetary sciences
BIO/CBM: biological sciences, chemical and biomolecular sciences
CHIR: chiropractic

The results suggest that it is reasonable to assume a level of homogeneity in most STEM cohorts' career development focuses and needs. Therefore, in embedding career development learning in curricular or extra-curricular contexts, one can argue that in general, a relatively consistent format or general approach to covering given developmental areas may work, regardless of the STEM discipline. Having stated this, mathematics, statistics, physics and astronomy students may need more tailored interventions in career development learning.

Comparing STEM students' and employers' career information literacy focus

Contrasting student and employer responses, we found both students and employers highly value self-awareness in generic learning, transition learning in discipline-based learning, and opportunity awareness in transition learning. However, students had high career development focuses related to discipline-based learning, while employers emphasised these focuses in transformative learning.

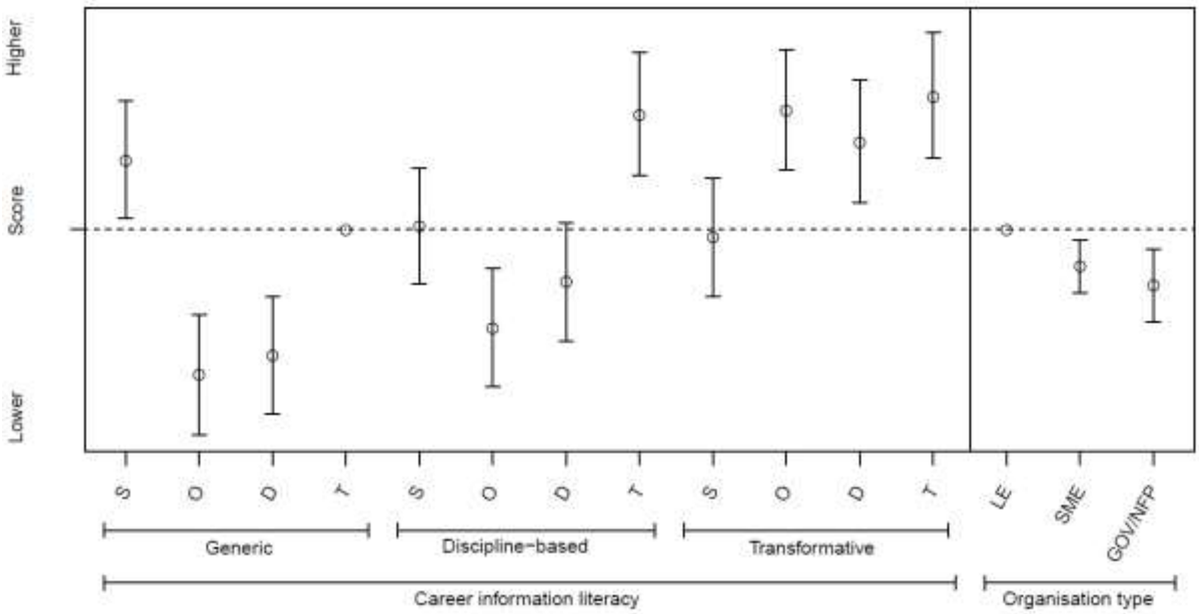

Figure 2: Career information literacy focus by organisation type- STEM employers
S: self-awareness; O: opportunity awareness; D: decision making; T: transition learning
LE: Large enterprise; SME: Small and medium enterprise; Gov/NFP: Government, Not for profit organisation

Comparing Figure 1 and 2, the plots of STEM students' and employers' career information literacy focus point to very different directions, thus answering our second question. STEM students and employers share different foci of career development.

Students viewed their discipline-based career information literacy as most important, while employers only viewed one of these discipline-based career information literacies as important as students, which is students' ability to effectively show how they can add value to employers based on their studies. This reflected a gap in student knowledge, suggesting a potential over-reliance on the perceived value of technical degrees.

Employers did share the same focus as students on students' general self-understanding, and motivation and ability to contribute to any work in a meaningful way. However, they were much less concerned with students' knowledge of broad career options, their knowledge of specific work opportunities and industry requirements related to degrees and their ability to evaluate preferred career choices.

It was intriguing to see that these attributes were not as important as other career information literacies for employers. In a follow-up with a number of STEM employer respondents, we asked them why these attributes could be considered as relatively unimportant by employers. The employers indicated that from their perspective of recruiting targeted students, the students only needed to know about their organisations, not their competitors; therefore, no need to know about a wide range of opportunities. In this regard, we note that there may be a potential conflict of interests between students and employers. The role of educators will be to make sure students are aware of the different perspectives to make informed career development decisions.

Conclusion

Two concerns of STEM student employability are addressed in this study. The first is the level of career development learning focuses amongst different STEM student cohorts. The second is the gap between STEM students and employers on these focuses.

The Career Information Literacy approach was used to assess students' and employers' career and employability development focuses. The results showed that in general, most STEM student cohorts do not differ from each other in their career information literacy learning focus, with the exception of the mathematics, statistics, physics and astronomy cohort. They exhibited much lower CIL focus than their STEM peers. Contrasting students and employers CIL focus, it was clear that STEM students and employers had different emphases.

The study provides two important implications for curriculum design. Firstly, it can be argued that regarding designing and facilitating career intervention, there is significant common ground for STEM student in satisfying their expectations and needs. However, groups identified as having lower levels of awareness in career development learning may require earlier, special or additional intervention. Secondly, students need to be educated about the incongruent career and employment focuses held by employers and students, but educators need to balance students' and employers' interests.

We note several limitations to this study. Firstly, due to the sample size, the study is limited to analysing the discipline results in groups only, by combining closely-related disciplines. Secondly, capstone unit students may not be representative of all STEM students at this faculty. Thirdly, the study was done in one single institution; therefore, we were limited in generalising the findings for other STEM students. Lastly, likewise, our STEM employer sample was based on proactive employers who approached this faculty to recruit and engage students; therefore, may not be representative of all STEM employers.

It would be beneficial to investigate if students who enter different degree programs already come with certain pre-dispositions for, or conceptions of career development. This could only be confirmed by also sampling first year students in future studies. It would also be beneficial to replicate this study in non-STEM disciplines to compare STEM and other student cohorts' focuses on career development learning. Such further studies may improve the generalisability of the approach and findings; whilst providing insights for facilitating career and employability learning within the curricula.

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Appendix 1: The twelve career information literacy items in the student and employer survey

For students:

How important are the following to you for your next career move (work, study, other plans)?

Understanding your own interests, skills, values, strengths, etc.
Your discipline-based knowledge, skills and approaches
Critical reflective ability on your motivation and behaviour in making career transitions
Knowledge of broad career options
Knowledge of specific work opportunities & industry requirements to which your disciplinary learning would be an asset
Motivation and knowing how to contribute to any work in a meaningful way
Ability to evaluate your preferred career choices
Ability to target specific work, based on relevance of your personal profile, experiences, circumstances and capabilities
Ability to think outside of the box in career decision making
Sound skills to handle job application & recruitment process
Ability to effectively show how you can add value to an employer from your discipline-based learning
Ability to challenge your existing practices and take critical actions to adapt to changing environments
Other (please specify):

For employers

What do you value in a candidate?

Their self-understanding of interests, skills, values, strengths, etc.
Their discipline-based knowledge, skills and approaches
Critical reflective ability on one's motivation and behaviour in making career transitions
Knowledge of broad career options
Knowledge of specific work opportunities & industry requirements to which one's discipline-based learning would be an asset
Motivation and knowing how to contribute to any work in a meaningful way
Ability to evaluate one's preferred career choices
Ability to target specific jobs, based on relevance of one's personal profile, experiences, circumstances and qualifications
Ability to think outside of the box in career decision making
Sound skills to handle job application & recruitment process
Ability to effectively show how one can add value to an employer based on who they are and what they study
Ability to challenge one's existing practices and take critical actions to adapt to changing environments
Other (please specify):

Respondents select from answer items of 'strongly disagree', 'disagree', 'neutral', 'agree', and 'strongly agree'.