Perceptions of Transferable Skills among Biomedical Science Students in the Final-Year of Their Degree: What are the Implications for Graduate Employability?

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Abstract

Faced with growing career uncertainty, science, technology, engineering and mathematics (STEM) graduates are increasingly reliant on transferable skills, including communication, teamwork and critical thinking, to thrive in a dynamic, unpredictable workforce. While discipline-specific technical skills and knowledge remain cornerstones for STEM graduates, the ability to use transferable skills to adapt to changing work paradigms is an increasingly valuable competency. However, the relevance of transferable 'employability' skills to employment within STEM disciplines is often overlooked in teaching. We examined final-year Biomedical Science student perceptions of necessary work capabilities, prior to, and following, a compulsory capstone unit with a central focus on developing transferable skills. Results from pre- and post-unit surveys showed that students; 1) rated transferable skills over discipline knowledge or technical skills for future employment, 2) rated communication skills as most important in future careers, 3) felt that they had improved their transferable skills throughout their degree, 4) developed these skills in both assessed and non-assessed learning activities, and 5) could identify specific examples of transferable skills found in workplaces. We suggest an explicit focus on transferable skills, using capstone units of STEM degrees, to develop transferable skills in final-year students and consequently improve graduate employability and future work success.

Introduction

Young Australians' face unprecedented work uncertainty due to growing globalisation, rapid technological disruption, and socio-economic transformations (Beer et al., 2016; CEDA, 2015; CSIRO, 2016; Hajkowicz et al., 2016; WEF, 2016). It has been reported that nearly 60% of students are studying for occupations that may not exist in a decade (Durrant-Whyte, McCalman, Olaghan, Reid, & Steinberg, 2015; FYA, 2015). Transferable skills are skills which are relevant across every profession, are increasingly valued by employers over discipline-specific technical skills and knowledge (AACU, 2015; Rayner & Papakonstantinou, 2015), and include skills in communication, teamwork and critical thinking. Recent studies have shown that young Australians appear to be lacking the key transferable skills required to thrive in the current and future globalised workforce (FYA, 2016; Randstad, 2017). It has been suggested that university programs could improve graduate employability by focusing on and

building transferable skills (Bennett, Richardson, & MacKinnon, 2016; Choate, Green, Cran, Macaulay, & Etheve, 2016; FYA, 2016; NCVER, 2002).

Communication is one of the most widely valued transferable skills amongst employers and will undoubtedly continue to be a key transferable skill in the 21st Century workforce (FYA, 2016; Prinsley & Baranyai, 2015). In a study involving science students, Mercer-Mapstone and Kuchel (2015) found that communication skills were taught more explicitly in tasks aimed at non-scientific audiences, as well as group and multimedia tasks, as opposed to individual, written or oral tasks. In a further study, Mercer-Mapstone and Matthews (2017) examined undergraduate science students' perceptions of communication skills and found that while students agreed that these skills were important, they felt that oral communication skills were included less in the curriculum than scientific writing. This study found that there was a lack of coherent opportunities for students to learn and develop communication skills across the curriculum.

Teamwork abilities are a competency of growing value to employers in increasingly complex and integrated professions (Allen Consulting Group, 2010; West, 2012). In a broad study of Australian university coursework by Rayner and Papakonstantinou (2016), teamwork was listed most often within the interpersonal skills classification. Yet there are disparities between student perceptions of teamwork competencies and those of employers (AACU, 2015; Jang, 2016). Attempts to improve teamwork competencies through capstone programs have been successfully demonstrated (Eppes, Milanovic, & Sweitzer, 2012). It is clear that in order for science, technology, engineering and mathematics (STEM) graduates to thrive in the contemporary workforce they will need very well-developed teamwork abilities (Pellegrino & Hilton, 2012).

Critical thinking is regarded as one of the most important skills expected of science graduates, as well as higher education graduates more broadly (Facione & Facione, 2008; Halper, 2002). In order to foster critical thinking skills in students, teaching approaches require the use of innovative methods that scaffold and explicitly teach these skills (Belluigi & Cundill, 2017; Golding, 2011). Evidence has also shown that teacher role-modelling of critical thinking with real world problems, and opportunities for students to participate in open-ended discussions, can foster the development of critical thinking in high school students (Barak, Ben-Chaim, & Zoller, 2007). Given the increasing unpredictability of jobs and the uncertainty around the types of technical skills that will be required to thrive in the workforce, well-developed abilities in critical thinking may offer the best chance to prepare graduates for their future careers (Ramsey & Baethe, 2013).

In the Biomedical Sciences, as in other STEM disciplines, there are challenges in preparing students for the workforce given the changing nature of work, particularly in traditional STEM areas such as research, which are currently depressed due to funding cuts by government (Winefield, Boyd, Saebel, & Pignata, 2008; Rayner & Papakonstantinou, 2015). Indeed, many STEM graduates do not work in professions directly related to STEM, highlighting the need for undergraduate STEM degree-programs to include a focus on the development of transferable skills (Greenwood, Harrison, & Vignoles, 2011; Randstad, 2017). Transferable skills are included in the Australian Science Threshold Learning Outcomes that all science graduates are expected to attain during their undergraduate studies (ACDS, 2011). However, a study of graduating science students by Varsavsky, Matthews and Hodgson (2014) elucidated that student perceptions of the importance of skills such as communication and teamwork were greater than perceptions of improvement, confidence and future use. Indeed, there exists

significant gaps between graduates and employers in the level of transferable skills competency required in the workforce (AACU, 2015). Furthermore, the perceptions of Biomedical Science students concerning the relevance of transferable skills to work and their development during their degree has not been well explored.

While the cohort of Biomedical Science students investigated in this study are required to undertake a broad professional development program throughout their degree (Choate, Green, Cran, Macaulay, & Etheve, 2016), there is an emerging consensus that transferable skills such as communication, teamwork and critical thinking are best developed within a discipline, as this provides fundamental context around their application (Jones, 2009). It is also suggested that transferable skills development within the curriculum should be made explicit to students during their learning (Jahn & Kenner, 2018). This study aims to assess student understanding of transferable skills and their perceived development of transferable skills while undertaking a core capstone unit in a Biomedical Science degree in which the development of transferable skills is a central and explicit focus. We hypothesise that embedding transferable skills development in this capstone unit will enhance the perception of transferable skills among students, potentially improving graduate employability.

Methodology

A mixed methods approach was employed. Pre- and post-unit surveys explored student understanding and perceptions of transferable skills, and ratings of the importance of these skills in their future career. Surveys contained a combination of questions (Table 1) using dichotomous, Likert scale (4- and 10-point) and open-ended responses. Survey questions were developed with reference to previous studies (Mercer-Mapstone & Matthews, 2015; Rayner & Papakonstantinou, 2015; Saunders & Zuzel, 2010). Classification of workplace-specific and general workplace skills were determined by alignment with definitions and descriptions described elsewhere (Bridgstock, 2009; FYA, 2016). The post-unit survey contained a number of additional questions which became relevant only after students had completed the unit. The pre-unit survey (Week 1 of semester) and post-unit survey (Week 12 of semester) were administered in hard copy to students at the beginning of a tutorial class. Students were enrolled in a final-year compulsory capstone unit with a credit point weighting equivalent to 50% of a full 12-week semester study load. The capstone unit had an enrolment of 379 students of which 44.3% were male and 55.7% were female.

The capstone unit focused specifically on building transferable skills throughout twelve three-hour workshops in classes of 20 students facilitated by a Teaching Associate. Each workshop encompassed active learning exercises and a related assessment designed to develop transferable skills. These included; team problem solving activities, data graphing exercises, graphic design of molecular pathways, oral presentations, researcher interviews, figure design, report writing, ethical debates, cases studies, news analysis, literature research, and lay audience writing. Each week, students were assessed on their communication, teamwork and critical thinking abilities through both in-class observation and submission of assessment tasks in which they were able to demonstrate their capabilities. The survey items were analysed using IBM SPSS software, and graphs created using GraphPad Prism 7 software. Data was excluded from analysis if students had incorrectly selected multiple options for questions requiring a single answer. Written comments from the surveys were initially coded by a research assistant. The coded data was analysed and discussed by three investigators and a consensus was formed to categorise comments into relevant themes. Ethics for this study was approved by the Monash University Human Research Ethics Committee (#7954).

Table 1: Survey questions used in the pre- and post-unit surveys to measure student perceptions of transferable skills.

Questions (pre-unit survey only)
During your Biomedical Science degree, how much improvement have you made in your [communication/teamwork/critical thinking] skills?
In your Biomedical Science degree to date, how effective were [assessment tasks/ non-assessed learning activities] in helping you to develop general workplace skills?;
Reflecting on your Biomedical Science degree to date, how have you developed general workplace skills such as communication, teamwork and critical thinking?
What is your current understanding of employability skills?
Questions (pre- and post-unit survey)
What is your gender?
My primary career preference is:
When I graduate from this course I intend to:
Which of the following skills do you think will be the most important in your future employment? [Communication, Teamwork or Critical thinking]
In your future employment, which of the following do you think will be more important? [Biomedical content knowledge and understanding, Biomedical skills or General workplace skills]
To what extent do you think you will use general workplace skills such as communication, teamwork and critical thinking in your future career?
Evaluate whether the following examples are general workplace skills or workplace-specific skills

Results

Student profile

Of the total survey respondents, 197 were identified through a unique code to have completed both the pre- and post-unit surveys. These matched groups (n=197) were used in the analysis. Proportions of female and male students were similar in both surveys (pre-unit 59% female, 40.4% male; post-unit 58.5% female, 41.1% male). Most students who participated in the surveys, intended to continue studying at the conclusion of their current biomedical science degree (92.3% and 85.7% pre- and post-unit, respectively, Figure 1A), with a majority of the cohort (64.1% and 61.6% pre- and post-unit, respectively) nominating medicine as their primary career ambition (Figure 1B).

(A) **(B)**

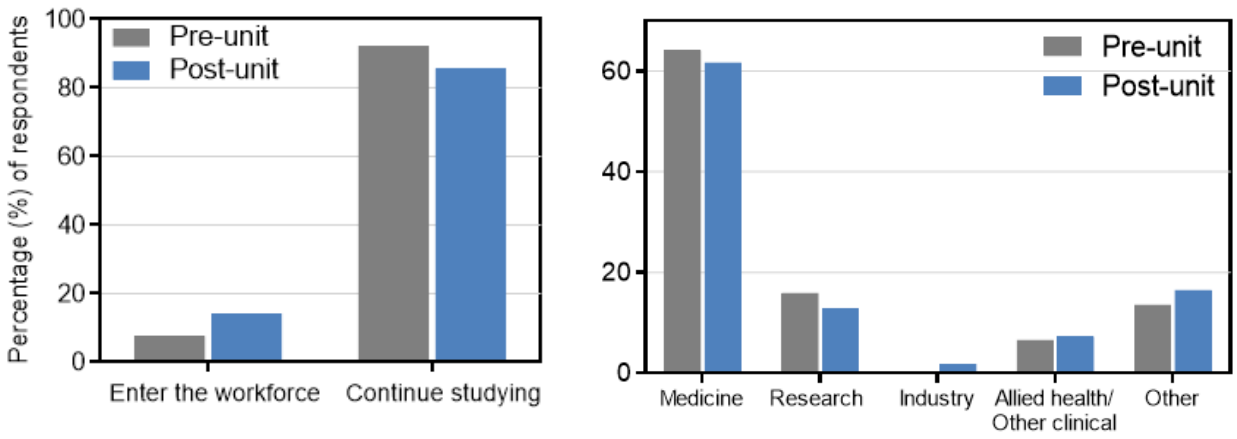

Figure 1: (A) Percentage of Biomedical Science students who wish to enter the workforce or continue studying after their undergraduate Biomedical Science degree. (B) Percentage of Biomedical Science students who listed career intentions in relevant categories (allied health/other clinical included nursing, pharmacy, dentistry, psychology, physiotherapy and social work).

Which skills did students think were important for their future employment?

Students were asked to identify which competencies they thought would be more important in their future employment; group 1- Biomedical content knowledge and understanding, group 2- Biomedical skills (e.g. laboratory techniques, bioinformatics programs, scientific method) or group 3- General workplace skills (e.g. communication, teamwork, critical thinking). In the pre-unit survey, 61.2% of students felt that general workplace skills were more important than biomedical content knowledge and understanding and biomedical practical skills (Figure 2). In the post-unit survey 70.9% of students rated general workplace skills as more important, which represented a 9.7% increase compared to the pre-unit survey, although this was not statistically significant. Additionally, a significant decrease (7%) in the percentage of students rating biomedical skills as more important was observed.

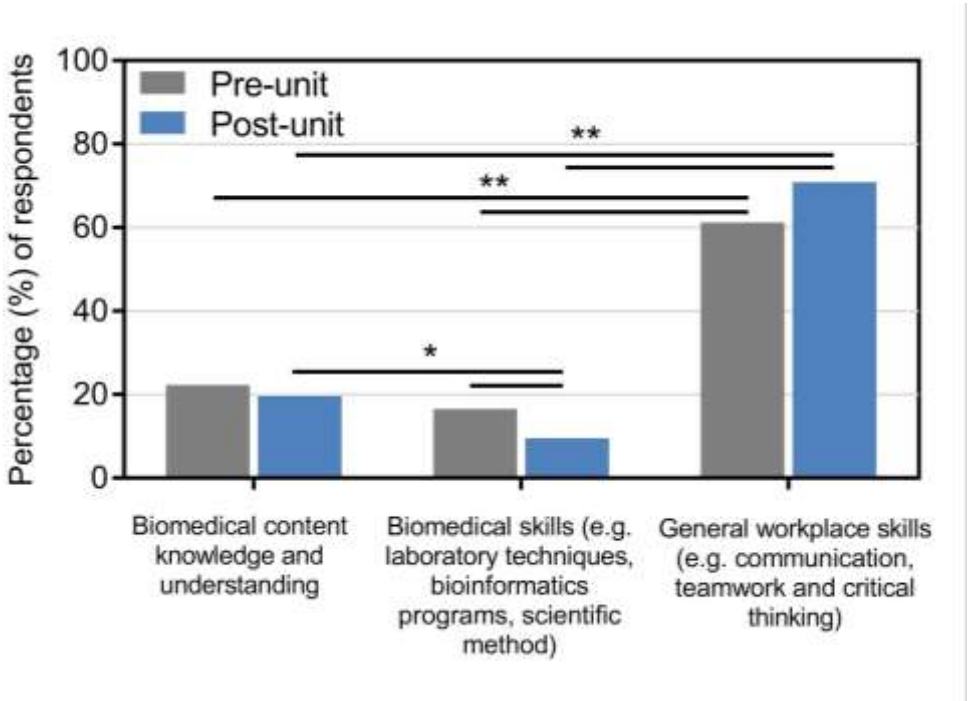

Figure 2: Biomedical Science students' perceptions of which capabilities will be most important in their future employment. X^2 test, *p=<0.05, **p=<0.01.

Students were asked to indicate on a scale of 1-4 (1 = very little, 4 = greatly; no descriptions were given for 2 and 3) to what extent they thought they would use general workplace skills in their future employment. In both the pre-unit and post-unit surveys students indicated that they would use transferable skills to a great extent in their future employment (mean ± SD: 3.87 ± 0.37 and 3.82 ± 0.44, pre- and post-unit, respectively). When students were asked to identify which general workplace skill they thought would be most important in their future employment, 58.4% indicated communication skills, while 28.6% indicated critical thinking and 13% indicated teamwork skills (Figure 3). Students did not alter their perceptions in the post-unit survey.

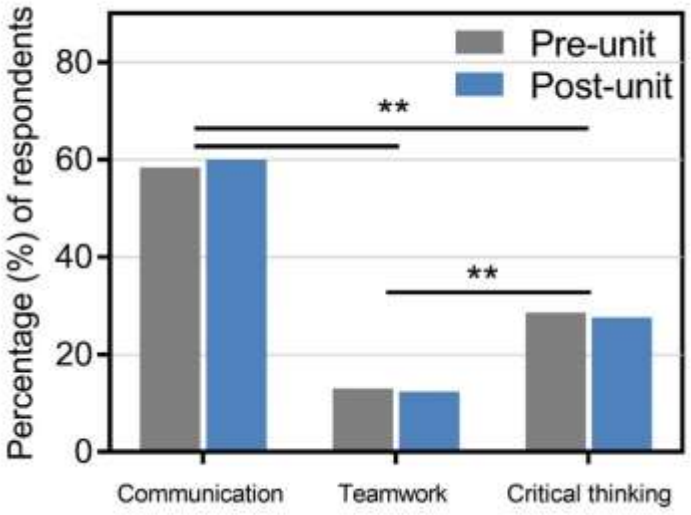

Figure 3: Rankings of importance of individual transferable skills in future employment, by Biomedical Science students prior to and following completion of the capstone unit. X^2 test, **p=<0.01.

How much improvement in skills do students perceive during their degree?
At the beginning of the third-year capstone unit, students were asked to indicate on a scale from 1-10 (1 = no improvement, 10 = great improvement, no descriptions were given for 2 - 9) how much improvement they thought they had made in each transferable skill during their Biomedical Science degree. Results showed that students felt they had achieved a moderate to large improvement in each of the three transferable skills; communication, critical thinking and teamwork (Table 2). Students were also asked to indicate on a scale of 1-4 (1 = not effective, 4 = very effective, no descriptions were given for 2 and 3) how effective different approaches to learning (assessment tasks or non-assessed learning activities) were for their development of transferable skills. Students gave an equivalent rating to assessment tasks and non-assessed learning activities for building transferable skills (Table 3).

Table 2: The improvement of specified transferable skills perceived by Biomedical Science students over their Biomedical Science degree program. Scale of 1 = no improvement to 10 = great improvement.

Transferable skill	Mean ± SD
Communication	7.05 ± 1.89
Critical thinking	7.30 ± 1.66
Teamwork	7.21 ± 1.79

Table 3: The effectiveness of different approaches to learning on the development of transferable skills perceived by Biomedical Science students over their degree program. Scale of 1 = not effective to 4 = very effective.

Approaches to learning	Mean ± SD
Assessment tasks	2.70 ± 0.74
Non-assessed learning activities	2.62 ± 0.78

These results were supported by responses (n=102 respondents commented) to the open-ended question, "Reflecting on your Biomedical Science degree to date, how have you developed general workplace skills such as communication, teamwork and critical thinking?" Students thought workplace skills such as communication, teamwork and critical thinking were seen as having improved in their degree to date through participatory activities such as tutorials (7.8%), team-based activities (17.6%), group oral presentations (25.5%), group assignments (24.5%), peer interactions in study groups (12.7%) and communicating with professionals (2%). Other comments were general and did not address the question. Examples of responses include, "Greater number of opportunities to work in a team and to manage differences in opinion and perspective, and to communicate with professionals", "Through assessment tasks mainly e.g. orals, essays, projects, lab sessions, etc.", "The small group sessions with case studies were great for all those aspects." Students described some ways in which these team-based

experiences impacted their behaviours and increased their confidence, “Through building confidence in group situations”, “Having to do a lot of oral presentations has helped improving the way I convey a topic to others”, “I can talk to people I've never met with ease, and work with them”.

What skills do students perceive as transferable employability skills?

At the start of the unit, students were asked about their current understanding of employability skills. 109 respondents commented on their current understanding of employability skills. Over 25% gave vague or non-specific answers such as “skills favoured by employers.” Others (20%) perceived that employability skills were “general skills, not job specific, that assist in delivering content, completing tasks and communicating with colleagues.” More informed students (20%) correctly identified employability skills as transferable skills, “Otherwise known as enterprise skills, they are transferable skills across jobs and paramount in the current workforce” (male, double degree student). Around 25% of students specified the content of transferable skills; “Employability skills are non-technical or [non] biomedical science specific skills- such as communication, teamwork and critical thinking” (female, single degree student), “Good communication skills, ability to follow orders, general respect for the occupation, ability to work individually as well as work in a team” (female, double degree student), “Communication, teamwork, critical thinking, to improve efficiency and effectiveness in the workplace, allowing us to get a better job” (male, double degree student).

At the beginning of the unit, students were asked to classify ten specific descriptions of skills as either ‘general workplace’ (transferable) or ‘workplace-specific’ (discipline) skills. More than 70% of students identified “Assessing information to determine its usefulness”, “Evaluating evidence to make a decision”, “Presenting data in the form of a graph”, “Compiling the essential components of a report into a one page summary” and “Determining whether data is reliable” as transferable skills (Figure 4). Pipetting accurately was correctly recognised by 96.8% of students as being a workplace-specific skill. At the end of the unit, students were again asked to classify these ten specific descriptions of skills. The number of students who correctly identified two of the workplace-specific skills (“Presenting experimental data to colleagues” and “Measuring and collecting data”) in the pre-unit survey, had declined in the post-unit survey, changing toward the incorrect classification of general workplace skill. However, for six of the seven general workplace skills, small, but not significant, improvements were observed in the proportion of students who could correctly identify these as general workplace skills in the post-unit survey (Figure 4).

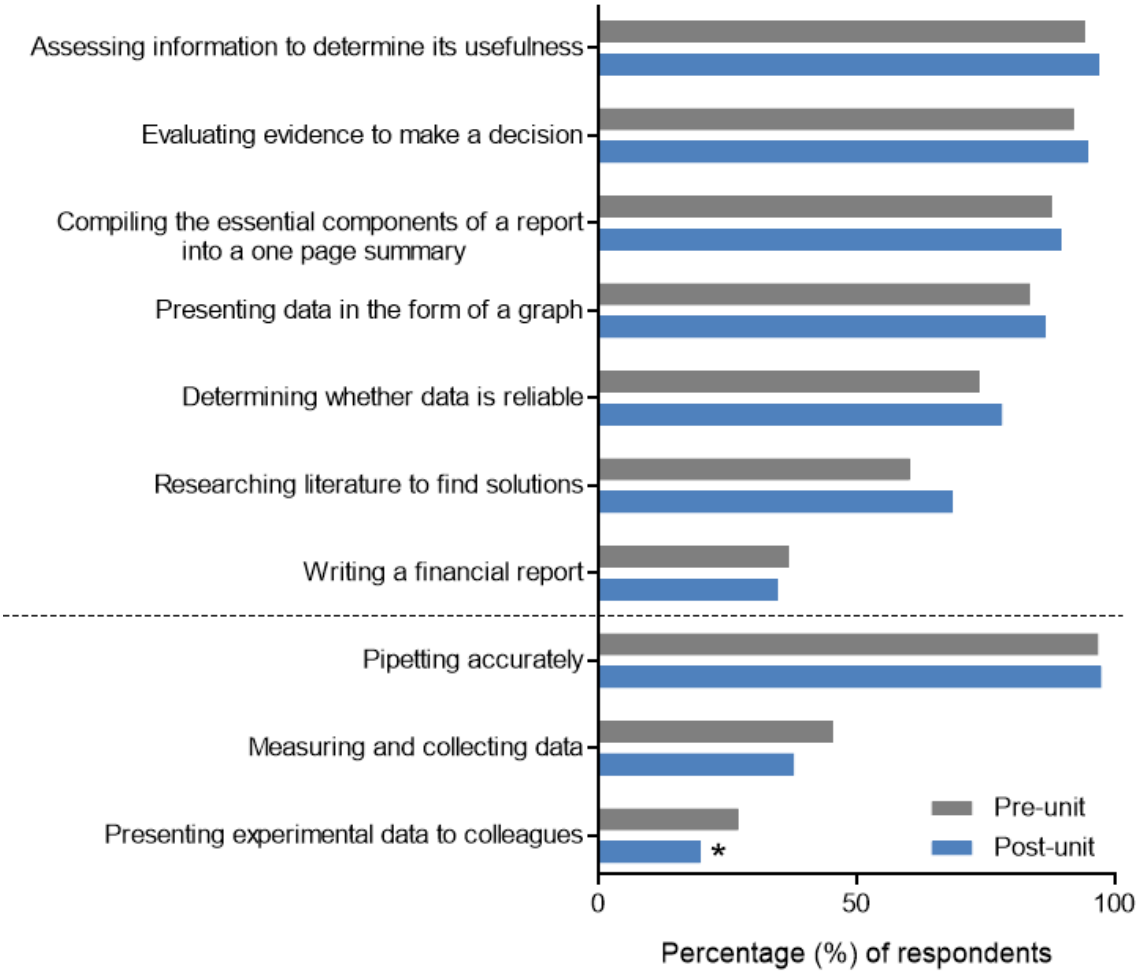

Figure 4: Percentage of students pre- and post-unit who correctly classified ten specific descriptions of skills as general workplace (transferable skills, above the dotted line) or workplace-specific (discipline skills, below the dotted line). Related samples Wilcoxon signed rank test, *p<0.05.

Discussion

This study has examined final-year Biomedical Science student perceptions of transferable skills, focusing on communication, critical thinking and teamwork, as they approach the conclusion of their degree. The study has evaluated student understanding of these skills prior to and after completing a newly implemented capstone unit. The key findings from this cohort were that; 1) most students correctly identified specific examples of transferable skills, 2) students perceive transferable skills to be more important in their future employment, compared to discipline-specific knowledge or technical skills, 3) students perceive that they had made moderate to large improvements in their transferable skills throughout their degree, 4) students rated communication as the most important transferable skill in their future career, followed by critical thinking and then teamwork, and 5) students feel that assessed tasks are equally as effective as non-assessed learning activities in developing transferable skills.

Identification of transferable skills

An explicit focus on building transferable skills in the Biomedical Science course is not present prior to completing the capstone unit. In this context it was surprising that most students in the

final year of their degree could correctly identify specific examples of workplace-specific and discipline-specific skills at the beginning of the unit. Although not significant, the small improvement in the ability of students to correctly identify transferable skills following the capstone unit suggests that the explicit focus on transferable skills may have had an impact on students' understanding of what characterises skills as workplace transferable. Despite the importance of students' understanding of transferable skills, there have been few reports characterising the ability of students to identify transferable skills. However, it appears that students generally have a narrow view of transferable skills (Tymon, 2013). Nonetheless, it is encouraging that students generally had a strong understanding of the difference between transferable and technical skills before beginning the capstone unit. This may suggest that less effort can be directed to building awareness of transferable skills, and more effort can be focused on explaining their relevance to work and in developing them through application.

Relevance of transferable skills

It was found that students perceived transferable skills to be more important in their future employment than discipline-specific knowledge and technical skills. They also indicated that they would use transferable skills to a great extent in their future employment. Given that the majority of students in this cohort intend to pursue medicine in their future careers, it was somewhat surprising that they perceived transferable skills to be more important than discipline-specific knowledge. Careers in medicine demand high-level discipline-specific knowledge and student admission into graduate medicine programs is largely based on discipline-specific knowledge. However, this may be explained by the nature of their current degree which focuses on the Biomedical Science knowledge which underlies health and disease, rather than the clinical skills and knowledge which many of the students intend to pursue with further study in medicine and allied health. It has been reported in other disciplines that students at university are becoming more aware of employer expectations in terms of transferable skills such as communication, critical thinking and teamwork (Kavanagh & Drennan, 2008; Tymon, 2013). Our findings indicate that Biomedical Science students are aware of employer expectations.

Improvement in transferable skills

Reflecting on their progress throughout their degree, students perceived that they had made moderate to large improvements in their transferable skills. This general perception of skill development throughout a STEM degree remained unchanged from an earlier study of final-year Science and Biomedical Science students who reported moderate improvement of communication (written and oral) and teamwork skills (Varsavsky, Matthews, K, & Hodgson, 2014). Interestingly, a study using focus group data reported that final-year Biomedical Science students from the same university felt that they had limited employability skills (Choate et al., 2016). These authors reported that first and second year students had perceived high capability in transferable skills and that final-year students were mostly confident in their general workplace skills competency. These findings indicate that there are adequate opportunities for transferable skills development in the course (Choate et al., 2016). However, it is known that employers generally find that graduates are much less prepared for work across a range of transferable skills than students perceive themselves to be (Hart Research Associates, 2015; Jang, 2016). Nonetheless, there is evidence from others to support the value of explicitly and purposefully incorporating learning activities into the curriculum to develop transferable skills (Golding, 2011; Choudhury & Gouldsborough, 2012; Eppes et al., 2012; Belluigi & Cundill, 2017).

Communication is the most important transferable skill

Communication, teamwork and critical thinking are three of the top transferable skills sought by employers (Robles, 2012; Carnevale & Smith 2013). Closer examination of Biomedical Science students' perceptions of the importance of these three transferable skills suggests that students view communication as the most important transferable skill for their future career, followed by critical thinking and then teamwork. The findings related to communication skills are supported by the study of Mercer-Mapstone and Matthews (2015) in which students in an undergraduate science degree also gave high ratings for the importance of communication skills in their future careers. However, the finding that communication is more important than critical thinking or teamwork contradicts a UK study of employability skills by Saunders and Zuzel (2012) in which Bioscience students ranked teamwork as more important than communication or problem-solving. This may reflect a real change in the importance of communication skills over time, or it may indicate that the relative importance of specific transferable skills is dependent on the context in which they are utilised.

Assessment is effective at building transferable skills

In the present study, when students were asked to rate the effectiveness of pedagogical approaches on the development of transferable skills, they rated assessment tasks and non-assessed learning activities equivalently. This finding contradicts the work of Leggett, Kinnear, Boyce and Bennett (2004) who reported a strong link between the frequency of assessment of a particular skill and the importance that students gave to that skill. Mercer-Mapstone and Matthews (2015) found that students gave lower ratings for the inclusion and assessment of communication skills in their degree program than they did for importance and future use. A corresponding study by Mercer-Mapstone and Kuchel (2015) on the same student group found that the explicit inclusion of communication skills was absent from 50% of assessment tasks in the degree program. This finding is of interest given the views of our students who claim that they developed their transferable skills (communication, critical thinking and teamwork skills) as effectively in assessment tasks as in non-assessed learning activities, particularly through group and team-based assessments. This highlights the important role of active learning activities alongside assessment tasks in skills development within the curriculum.

Are Biomedical Science students prepared for work?

While there is less certainty of the occupations that will exist in the future workforce, it is projected that there will be significant growth in STEM employment over the next decade (SMF, 2016). While there remains uncertainty about the degree to which STEM graduates are valued by employers for their discipline-specific knowledge (Greenwood, Harrison & Vignoles, 2011), it is becoming increasingly clear that the types of skills required to thrive in the contemporary workforce are rapidly changing (CEDA, 2015; CSIRO, 2016; WEF, 2016). In this era of work uncertainty there is growing need for graduates to develop skills outside of traditional discipline-based competencies (Bridgstock, 2009; Hajkowicz et al., 2016). Our approach to this capstone unit, in which final-year Biomedical Science students develop transferable skills in the context of their discipline, was designed to provide an opportunity for students to consolidate and apply discipline-specific knowledge while demonstrating key competencies in the transferable skills required for their future careers. This was achieved through a number of non-assessed learning activities and assessment tasks which explicitly emphasised the presence and relevance of transferable skills. This follows other successful models of final-year capstone units which provide opportunities for students to consolidate discipline knowledge in the final year of their degree, and to incorporate transferable skills so that students' workplace skills proficiencies can be explicitly developed and reflected upon (Holdsworth, Watty, & Davies, 2009).

The data from our study suggests that embedding transferable skills within capstone units can improve student awareness of the relevance of transferable skills for their future work. While the results indicate positivity in perceived notions of transferable skills abilities and understanding, it remains to be seen to what extent capstone units such as this develop actual competency in transferable skills, particularly as gauged by employers. It is also important to consider the limitations of a study of this nature, such as whether students were biased by previous survey questions in reporting their understanding of employability skills. It is important to recognise that the ability of transferable skills to improve graduate mobility within the workforce may also be under the influence of socio-economic factors such as gender and class (Morrison, 2014). Nonetheless, our results suggest that STEM educators should explicitly embed the development of transferable skills in capstone units in order to improve students' attainment of these skills and thereby their employability in a paradigm of work uncertainty.

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