Understanding attitudes to and increasing recognition and articulation of employability skills amongst science undergraduates

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Abstract

Chemistry and other science graduates are challenged by a highly competitive and rapidly changing employment market and many will have difficulty in finding relevant graduate level roles. Whilst demand for some fields is gradually increasing, there is currently a significant surplus of graduates for direct employment in many science disciplines in Australia. Science graduates require a range of employability (or transferable) skills in order to gain employment and succeed in the workplace, including communication, teamwork, critical thinking, problem solving, organisation, time management, independent learning, initiative, adaptability, creativity, commercial awareness, numeracy and IT skills. Not only must graduates possess these skills, but they must be able to clearly articulate them to be successful in the recruitment process. Many academics are providing opportunities for skill development within the undergraduate science curriculum. However, prior research suggests that students may not recognise curriculum-embedded skill development and many science graduates lack the ability to articulate their skills.

This study investigated the extent to which science undergraduates from Monash University and the University of Warwick recognise transferable skill development through the curriculum and understand the importance of such skills in employment. Open-ended survey questions showed that students could typically name three skills as developed during their degree or valued by employers from amongst communication, teamwork, thinking and problem solving, time management and laboratory skills. They failed to recognise that they had developed other skills or that employers are seeking graduates with a much greater breadth of transferable skills. This finding clearly establishes the need for intervention in the curriculum to widen students' skill recognition.

The study explored whether engaging students in written reflection on curriculum-embedded skill development or displaying skills badges on curriculum tasks could improve student recognition of skill development opportunities and their ability to articulate their skills. The impacts of these interventions were evaluated through pre- and post-intervention surveys and focus groups and interviews. The perceptions of teaching staff were also investigated.

The findings suggested that science students are discipline and task focused and unlikely to recognise transferable skill development unless prompted. Therefore, academics need to make explicit links between the curriculum, skills and employment and highlight that skill development is a key purpose of many curriculum tasks. The findings established that students' recognition of skill development may be enhanced by displaying skills badges on curriculum materials and to an extent through reflection. Reflecting on skill development experiences improved students' ability to articulate their skills. Students valued the connection to 'real life' and employment provided by the two interventions, with both leading to enhanced motivation and satisfaction. However, it is vital that teaching staff communicate the purpose and value of these initiatives to students to ensure most students engage with and benefit from them.

Declaration

This thesis is an original work of my research and contains no material which has been accepted for the award of any other degree or diploma at any university or equivalent institution and that, to the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

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Publications during enrolment

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Thesis including published works declaration

I hereby declare that this thesis contains no material which has been accepted for the award of any other degree or diploma at any university or equivalent institution and that, to the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

This thesis includes three original papers published in peer reviewed journals. The core theme of the thesis is understanding attitudes to and increasing recognition and articulation of employability skills amongst science undergraduates. The ideas, development and writing up of all the papers in the thesis were the principal responsibility of myself, the student, working within the School of Chemistry under the supervision of Professor Tina Overton.

(The inclusion of co-authors reflects the fact that the work came from active collaboration between researchers and acknowledges input into team-based research.)

In the case of chapters three to five, my contribution to the work involved the following:

Thesis Chapter	**Publication Title**	**Status** *(published, in press, accepted or returned for revision, submitted)*	**Nature and % of student contribution**	**Co-author name(s) Nature and % of Co-author's contribution***	**Co-author(s), Monash student Y/N***
3	**Undergraduate recognition of curriculum-related skill development and the skills employers are seeking**	Published	80%. Concept, data collection, analysis and primary author	1) Tina Overton, 10%, input into analysis and manuscript	N
				2) Christopher Thompson, 4%, edit of manuscript	N
				3) Russell Kitson, 4% data collection and grant acquisition	N
				4). Paolo Coppo, 2%, grant acquisition	N
4	**Evaluating the impact of reflecting on curriculum-embedded skill development: the experience of science undergraduates**	Published	80%. Program & research design, data collection, analysis and primary author	1) Tina Overton, 12.5%, input into program concept, analysis and manuscript	N
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5	**'They help us realise what we're actually gaining': The impact on undergraduates and teaching staff**	Published	75%. Research design, data collection, analysis and primary author	1) Tina Overton, 10%, concept, grant acquisition and input into analysis and manuscript	N
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	of displaying transferable skills badges			data collection and grant acquisition	
				3) Christopher Thompson, 4%, badge implementation and edit of manuscript	N
				4) Rowan Brookes, 2.5%, grant contribution and edit of manuscript	N
				5) Paolo Coppo, 1.5%, grant contribution	N
				6) Lynne Bayley, 2%, awarding badges implementation	N

I have not renumbered sections of published papers in order to generate a consistent presentation within the thesis.

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I hereby certify that the above declaration correctly reflects the nature and extent of the student's and co-authors' contributions to this work. In instances where I am not the responsible author I have consulted with the responsible author to agree on the respective contributions of the authors.

Main Supervisor name: Tina Overton

Main Supervisor signature: Date: 08/08/2020

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1 Introduction

The aim of the research reported in this thesis is to understand a lack of recognition by chemistry and other science undergraduates of many of the employability skills developed at university and to improve students' ability to articulate these skills in preparation for the employment recruitment process.

The Grattan Institute reported in August 2016 that the Australian job market for science graduates was limited, highly competitive and that many science graduates were likely to experience difficulty in finding relevant work after graduation (Norton, 2016). This view was supported by Australian Government data showing that between 2008 and 2017, the number of domestic students enrolled in natural and physical science higher education courses in Australia each year jumped from 64,800 to 101,200; an increase of 56% (Australian Government Department of Education and Training, 2019). Over the same period, the average Australian online monthly vacancies for science professionals plummeted by 67%, primarily due to a decline in the mining sector (Australian Government Labour Market Information Portal, 2019). Whilst the job market for science professionals has slowly improved since 2014, in July 2019 such vacancies were still 54% lower on average than in 2008 (Australian Government Labour Market Information Portal, 2019). This suggests that in Australia in 2019, on average there were approximately three times as many science undergraduates for each vacancy than in 2008.

In this very challenging employment environment, Australian science graduates will need to maximise their employability and be able to clearly communicate to employers that they will be able to meet their needs, in order to secure employment after graduation.

A number of recent studies have identified the key attributes desired by employers of STEM graduates (Deloitte Access Economics, 2014; Rayner & Papakonstantinou, 2015; Sarkar, Overton, Thompson, & Rayner, 2016). Such studies show that employers are seeking to hire science graduates with a range of well-developed transferable skills including problem solving, critical thinking, communication, teamwork, planning and organisational skills, commercial/business knowledge, technology/IT skills, leadership, adaptability, initiative and creativity. However, other recent research indicates that employers are finding that some graduates lack the depth or breadth of skills they are seeking (Ibo, 2014; Mellors-Bourne, Connor, & Jackson, 2011; Norton, 2016; Sarkar et al., 2016; Saunders & Zuzel, 2010).

Science graduates' transferable skills are particularly critical given that a significant proportion of such graduates will be employed in roles that primarily use their generic skills rather than discipline knowledge, with the Grattan Institute (Norton, 2016) stating that in 2015, just under half of Australian science graduates were working in a field outside the focus of their degree.

Thus, it would seem critical for their employability that science students recognise the transferable skills they have developed, that they have confidence in their ability to apply them and that they can communicate this to a range of prospective employers.

1.1 Employability and its key dimensions

Employability is presented in the literature as a concept distinct from that of employment. Graduate employment statistics (the proportion of graduates obtaining work after a certain time period) are often collected or monitored by governments and universities as one measure of how well universities are preparing graduates for the workforce. However, it is well recognised that

employment is strongly dependent on external economic forces and the labour market. These may vary locally, regionally, nationally, over time and by discipline and hence employment outcomes alone are not an appropriate measure of graduates' (or others') preparedness for the workforce (Yorke, 2006).

As pointed out by Sarkar et al. (2016), employability is a construct and there are a number of definitions presented in the literature. Hillage and Pollard (1998) acknowledge that whilst there isn't a single definition, literature suggests that employability is "about work and the ability to be employed", and it encompasses the ability to gain initial employment, maintain employment and obtain new employment if required. They also point out that in defining employability, the quality of employment is important, such that an individual is employed at an appropriate level of skill and remuneration. As a consequence of a review of the employability literature, Hillage and Pollard proposed the following definition of employability:

"In simple terms, employability is about being capable of getting and keeping fulfilling work. More comprehensively, employability is the capability to move self-sufficiently within the labour market to realise potential through sustainable employment. For the individual, employability depends on the knowledge, skills and attitudes they possess, the way they use those assets and present them to employers and the context (e.g. personal circumstances and labour market environment) within which they seek work" (Hillage & Pollard, 1998).

Hillage and Pollard's definition and research suggests that employability requires an individual to possess knowledge, skills and attitudes relevant to an employer and role, as well as the ability to effectively use these assets in the recruitment process. They identify that career management skills are very important including self-awareness, work opportunity awareness, decision making skills and 'transition skills'. They define 'transition skills' as job search skills, preparation of convincing application documents supported by evidence of relevant qualifications, references and work experience, interview techniques, and a realistic and adaptable strategic approach. Finally, they acknowledge that both a person's individual circumstances and external economic factors will impact an individual's ability to realise their employability.

Another commonly referenced definition of employability is that of Yorke (2006):

"Employability is taken as a set of achievements – skills, understandings and personal attributes – that makes graduates more likely to gain employment and be successful in their chosen occupations, which benefits themselves, the workforce, the community and the economy" (Yorke, 2006).

This definition acknowledges that the implications of employability extend beyond the graduate themselves, to the community and the local and national economy. It was based on the USEM model (Knight & Yorke, 2002; Yorke & Knight, 2006) which outlines four key components of employability:

- Understanding of the relevant subject or discipline
- Skills (both discipline-specific and 'generic')
- Efficacy, self-beliefs and personal attributes (such as willingness to learn, resilience, persistence, adaptability and initiative) and
- Metacognition, including self-awareness of learning and the capacity to reflect on and learn from experience, one's own performance and that of others

The above definitions of employability have been further developed in more recent literature using employability models that attempt to name, succinctly describe and map out all of the key dimensions of employability.

Dacre Pool and Sewell (2007) propose a "CareerEDGE" model of employability consisting of nine components, each of which they suggest is essential in order to fully realise an individual's employability: Career development learning, work and life Experience, Degree subject knowledge and skills, Generic skills, Emotional intelligence and the ability to reflect on and self-evaluate each of these components, leading to self-esteem, self-confidence and self-efficacy. Whilst there is significant overlap with the Yorke and Knight model, the CareerEDGE model explicitly incorporates two additional components; career development learning and work and life experience. In the CareerEDGE model, the purpose of career development learning is to increase self-awareness of interests and motivations and understanding of how to research employment markets, present one's self well to employers and make career decisions (referred to by Hillage and Pollard collectively as 'career management skills'). Dacre Pool and Sewell highlight work experience as being valued by employers and emphasise the need for students to be provided with guidance about how their work and life experience can be used to enhance their employability. Both this model and that of Knight and Yorke include reflection as a key component of developing employability, with the CareerEDGE model emphasising the important mediating role of reflection in 'converting' the other graduate 'asset classes' into the self-belief and confidence necessary to obtain employment and succeed in a career.

Similar to the 'career development learning' element of the Dacre Pool and Sewell CareerEDGE model, Bridgstock (2009) emphasises the importance of career management behaviours as a key to employability, in addition to discipline specific skills and generic skills. Bridgstock describes career management behaviours as an individual's ability to self-evaluate their values, abilities, interest and goals and to find and apply information about work and careers to gain employment and advance through a career. She includes the ability to effectively present one's skills and experience to employers and to develop and maintain relevant professional relationships.

Two recent models of graduate employability include types of 'capital'. Clarke (2018) identifies both 'human capital' and 'social capital' as important for employability, with 'human capital' encompassing skills and work experience and 'social capital' referring to aspects of an individual's social standing that may impact their employment prospects including, networks, social class and university ranking. The latter is a new addition on prior models, although Bridgstock (2009) mentions the development of professional networks within the context of career management behaviours. In addition to these two forms of 'capital', Clarke includes individual attributes (common to other models) and individual behaviours such as career-building skills and self-management, similar to Bridgstock and Dacre Poole and Sewell. Clarke's model also includes 'perceived employability' as a factor, impacted by the other key elements (human and social capital and individual attributes and behaviours), and also explicitly acknowledges labour market forces (supply and demand) as a key dimension that impacts an individual's employability and employment and career outcomes.

Tomlinson (2017) discusses employability in terms of "how and why graduates succeed in the employment market". He conceptualises graduate employability in terms of five interactive forms of 'capital', which he defines as "key resources that confer benefits and advantages onto graduates". His graduate capital model for understanding graduate employability includes 'human', 'social', 'psychological', 'identity' and 'cultural' capital dimensions. Similar to Clarke's model, 'human capital' incorporates graduates' knowledge and skills which Tomlinson acknowledges are "a foundation of their labour market outcomes". Tomlinson also combines 'career-building skills' (including labour market familiarity, how to apply for work, opportunity awareness and the ability to articulate skills and link to targeted jobs), within this form of capital, whilst Bridgstock and Clarke specify it as a separate component.

Tomlinson's 'social capital' is seen as a graduate's social relationships and network, similar to Clarke's, including links through family, peers, community, university and work experience and the ability to recognise and utilise such resources when looking for employment.

'Psychological capital' is defined by Tomlinson as encompassing resilience (the ability to withstand set-backs and challenges in gaining employment and during a career), adaptability and flexibility (when experiencing career uncertainty and work transitions, including the ability to learn from others, engage in new experiences and adapt goals) and self-efficacy (self-belief regarding their ability to achieve their career goals and manage challenges that arise). These types of attributes are incorporated within the USEM, Clarke and Dacre-Sewell's model as 'efficacy and personal attributes', 'individual attributes and perceived employability' or emotional intelligence and self-efficacy.

The two dimensions of Tomlinson's model that are not commonly explicitly articulated in other employability models discussed are 'identity capital' and 'cultural capital'. Tomlinson defines 'identity capital' as "the level of personal investment a graduate makes towards the development of their future career and employability" and includes "their abilities to draw on experiences and articulate a personal narrative which aligns to the employment domains they seek to enter". This seems to have some overlap with career building skills (within Tomlinson's 'human capital' dimension) and with career development behaviours as articulated in the Dacre Poole and Clarke models. However, it is extended further within the Tomlinson model into the formation of a professional identity (self-identity and capability regarding work and career) and the ability to articulate that. The importance of professional (or in the case of undergraduates or new graduates, pre-professional) identity formation in enhancing graduates' employability is also argued by Jackson (2016) and Stott, Zaitseva, and Cui (2014), with Jackson defining 'pre-professional identity' as "an understanding of and connection with the skills, qualities, conduct, culture and ideology of a student's intended profession" and "the sense of being a professional".

Tomlinson defines 'cultural capital' as "the formation of culturally valued knowledge, dispositions and behaviours that are aligned to the workplaces that graduates seek to enter". It is discussed as potentially including achievements and experiences that may be seen by some employers to add distinction or additional value to a job candidate or potential employee (beyond higher education qualifications), such as prizes, awards, conference attendance or other achievements. It is also defined as comprising behaviours and interpersonal interactions that can be seen to exemplify the values of the target organisation, sector or employer. It includes the ability to detect and understand such values as well as the ability and confidence to articulate and demonstrate them.

1.2 Employability skills and transferable skills

Each of the definitions and models of employability outlined in section 1.1 include the concept of skills; both 'hard' skills (technical or practical skills relevant to a particular discipline) and 'soft' or 'employability' skills (relevant to a range of disciplines). Examples of employability skills include written and verbal communication, problem solving, critical thinking, organisation, time management, teamwork, leadership, creativity, digital/ICT, numeracy/data analysis, independent learning, resilience, commercial or business awareness and flexibility and adaptability (Deloitte Access Economics, 2014; QS Intelligence Unit & Institute of Student Employers, 2018). Such skills are referred to collectively in the literature by a variety of names including generic, core, soft, key, 21st century, professional, work ready, enterprise and transferable skills (Jackson, 2014b; Wakeham, 2016). They refer to skills which are required broadly across jobs, roles, employers, organisations and sectors, regardless of discipline. They are critical for success in the workplace (Deloitte, 2019; QS

Intelligence Unit & Institute of Student Employers, 2018; The Foundation for Young Australians, 2016) and academic/research careers (Taber, 2016) and employers require applicants to articulate them in job applications (Harvey, 2005; Lowden, Hall, Elliot, & Lewin, 2011; Shulman, 2014). A Jackson (2014a) modelling study of Australian employment data for over 56,000 graduates concluded that in addition to technical expertise, 'generic skill mastery' is a significant factor in obtaining full-time employment for graduates, especially younger graduates (who generally have less life and work experience).

In this thesis, the terms 'employability skills' and 'transferable skills' are used interchangeably to collectively refer to these skills; the former because it makes an explicit link to the relationship between these skills and employment (which is particularly useful in student-facing communications), and the latter, as it emphasises that such skills may be applied across many contexts including education and employment and can help navigate change and challenges (Bridges, 1993; The Foundation for Young Australians, 2016).

There has been a lot of attention amongst higher education institutions, government and employers about the development of undergraduates' employability skills. Whilst such skills gained initial prominence as a pathway to enhancing graduates' employability and societal economic productivity and prosperity (DEST; ACCI; BCA, 2002; Fallows & Steven, 2000; Lowden et al., 2011; Yorke, 2006), they have garnered additional attention in recent years as a result of rapid changes in technology and globalisation that have disrupted traditional employment roles and models (The Australian Industry Group, 2018; The Foundation for Young Australians, 2015; World Economic Forum, 2016). Technological advances such as automation, machine learning and artificial intelligence are being used to replace routine and repetitive tasks, meaning that non-routine 'human' transferable skills (such as complex problem solving, critical thinking, communication, empathy, teamwork, leadership, interpersonal skills, innovation and creativity) have become increasingly important and are forecast to become in even greater demand (Deloitte, 2019; The Foundation for Young Australians, 2016, 2017). In addition to these skills, the ability of individuals to learn continually, be independent, confidently negotiate a variety of digital technologies and environments, use data to understand, communicate and solve problems, and to adapt and transfer their skills to modified roles or new jobs as they evolve, will be critical for graduates' own employability as well as for organisational success, innovation and the sustainability of the economy (Cunningham, Theilacker, Gahan, Callan, & Rainnie, 2016; World Economic Forum, 2018).

There is significant overlap between employability skills and graduate attributes. Bowden, Hart, King, Trigwell, and Watts (2000) define graduate attributes as "the qualities, skills and understandings a university community agrees its students would desirably develop during their time at the institution and, consequently, shape the contribution they are able to make to their profession and as a citizen". Bridgstock (2009) breaks this definition into two components: attributes that assist a graduate to be a good citizen who contributes to a cohesive and just society, and attributes that enable a graduate to obtain and maintain work and positively contribute to a profession, the latter being employability skills and attributes. Much of the literature regarding the development of graduate attributes discusses the development of employability or transferable skills (Cousins, Barker, Dennis, Dalrymple, & McPherson, 2012; Kensington-Miller, Knewstubb, Longley, & Gilbert, 2018; Oliver & Jorre de St Jorre, 2018; Windsor, Rutter, McKay, & Meyers, 2014).

A criticism of the 'skills agenda' (Boden & Nedeva, 2010; Holmes, 2001; Tomlinson, 2010) is that focusing solely on the development of employability skills of graduates is too narrow. Critics state that a 'skills focus' does not adequately encompass the wide-ranging benefits gained from higher education and is insufficient to fully or sufficiently develop graduates' employability, as other

employability dimensions are required (as described in section 1.1). However, every definition and model of graduate employability necessarily includes transferable skills and attributes, as research amongst both employers and graduates clearly identifies them as a key element of graduate selection criteria. Recruitment processes typically identify a list of transferable skills that must be evidenced by graduates in the application and interview process and such skills are necessary for success in the workplace (Overton & McGarvey, 2017; Sarkar et al., 2016). The focus on identifying and articulating transferable skills in this thesis does not presuppose that such skills are the only characteristics graduates must develop to be successful in gaining a graduate position and managing their career; it merely acknowledges that this area is a weakness for many science students that it is critical to try to rectify in order to improve their employability.

1.3 How higher education institutions are addressing graduate employability

There are a number of approaches taken by higher education institutions to assist undergraduates to prepare for employment (Bradley et al., 2020; Gunn, Bell, & Kafmann, 2010; O'Leary, 2017; Yorke & Knight, 2006). Some institutions take an 'embedded' approach, wherein tasks that are designed to build employability skills and career readiness are embedded within units across the degree (Gunn et al., 2010; Higher Education Academy, 2016; Sarkar, Overton, Thompson, & Rayner, 2019; Windsor et al., 2014). Involving industry or other employers in some aspects of course delivery (such as guest speakers) is another embedded approach (Bennett, Richardson, & MacKinnon, 2015; O'Leary, 2013; O'Leary, 2017). Within this embedded approach, the employability initiatives may be embedded within a range of units or may primarily be addressed in compulsory 'core' units common to all students of a degree or major (Yorke & Knight, 2006).

Some institutions may take an 'add-on' approach, wherein specific employability units (either optional or compulsory) are created with the primary aim of helping students develop transferable skills, job application skills, career management skills and/or work readiness (Jackson, 2016). Such units near the end of a degree are often referred to as 'capstone' units and many of these have the development of work readiness as one of the key aims (Gilbert & Wingrove, 2019; Lee & Loton, 2019). Other employability-focused units may include internships or work placements at an employer's workplace which garner academic credit (Australian Council of Deans of Science, 2016). 'Sandwich degrees' in which students devote a significant block of time during their degree (such as a semester or a year) to undertaking relevant work experience at an external workplace are also motivated by developing student employability (Brooks, 2012; Jackson, 2015).

A third type of approach towards developing student employability is a 'separated' or 'parallel' approach, where assistance with work and career preparation is outside degree coursework. This is typically provided by the careers and/or volunteering departments and may involve career preparation training workshops, panels, programs and awards, sometimes with the involvement of external partners such as employers (Jackson, 2016; Jackson & Edgar, 2019; Miller, Jorre de St Jorre, West, & Johnson, 2017b).

Whilst three broad types of approaches are described above, each institution does not necessarily focus on one or another. Some institutions apply several or all of these approaches or specific faculties or degrees will embed or 'add on' employability initiatives in addition to the broader approach and offerings of the institution.

Work-integrated learning (WIL) has gained increasing prominence in recent years as a means for higher education institutions to help students develop employability and work readiness (Australian Council of Deans of Science, 2016; Jackson, 2015; Lasen, Evans, Tsey, Campbell, & Kinchin, 2018;

Oliver, 2015). WIL has been defined as "an umbrella term used for a range of approaches and strategies that integrate theory with the practice of work within a purposefully designed curriculum" (Patrick et al., 2008). Oliver (2015) suggests more specifically that WIL includes a range of learning tasks "that either resemble those expected of working graduates in their early careers, or are proximal to the workplaces or spaces, physical or digital, where professional work occurs". Aligning with the latter definition, activities may be considered as WIL either by their 'authenticity' (their alignment with actual workplace tasks) or 'proximity' (the closeness or involvement of students with those employed in a relevant role, industry or organisation) (Australian Council of Deans of Science, 2016).

In addition to a work placement or internship, WIL can include a range of activities embedded within the curriculum (Patrick et al., 2008). Examples of embedded WIL initiatives include on-campus projects on a workplace challenge or problem undertaken with a partner organisation, field work, role plays, simulations, case studies, work-related presentations or projects or other tasks based on an authentic workplace context, scenario or data (Lasen et al., 2018; Schonell & Macklin, 2019). Jackson (2015) reports that work placements, if effectively designed and supported by both the higher education provider and workplace supervisors and peers, assists student to develop, refine, understand and increase confidence in application of a range of essential workplace skills. Government and industry have called for an expansion of work-integrated learning initiatives in higher education because they are seen to help prepare students for the transition from education to employment by providing opportunities for students to experience, understand, develop, adapt and apply the skills and knowledge required in a relevant workplace context (Australian Council of Deans of Science, 2016). WIL experiences are also believed to enhance student confidence in their work readiness, help them gain an understanding of the workplace and evaluate different career options (Jackson, 2015). Research indicates that participating in WIL in the final year of undergraduate study may lead to short and long term higher quality, relevant employment (Jackson & Collings, 2018).

'Personal development planning' (PDP) is another employability-related initiative provided at some institutions, particularly in the UK, as a result of a recommendation in the Dearing (1997) Report by the National Committee of Inquiry into Higher Education (Strivens & Ward, 2010). The Quality Assurance Agency for Higher Education (2009) (QAA) define PDP as "a structured and supported process undertaken by an individual to reflect upon their own learning, performance and/or achievement and to plan for their personal, educational and career development". PDP may involve "personal profiling, personal and academic records, development plans, progress files, learning portfolios, eportfolios, learning logs, and diaries". The QAA state that engaging in PDP can help students "recognise, value and evidence their learning and development both inside and outside the curriculum" and "be better prepared for seeking, continuing or changing employment or self-employment and be more able to articulate the skills and knowledge they have gained to others". It may be optional or compulsory, embedded within a degree or a curriculum, separate from but linked to the curriculum at some points, or a parallel program administered by a centralised department.

Other higher education activities, within or outside the curriculum, which research has indicated may enhance employability (sometimes referred to as 'High Impact Practices' or HIPs) (Miller, Rocconi, & Dumford, 2017a), are undergraduate research projects with academic staff (which may be either 'for credit' or extra-curricular) , study abroad experiences, student leadership roles on campus and 'service learning' (where students complete a community service project and engage in reflection on their experiences as part of their degree). Research has indicated such initiatives may

increase students' employability by the development of transferable skills, assisting students to develop or identify an interest or passion they can pursue in employment and provision of opportunities to develop "stories" or experiences they can share with potential employers (Miller et al., 2017a; Möller & Shoshan, 2019; Wang, 2016). Another HIP which evidence suggests may enhance employability is participation in a 'learning community' which has been defined as "an intentionally developed community that exists to promote and maximize the individual and shared learning of its members. There is ongoing interaction, interplay, and collaboration among the community's members as they strive for specified common learning goals" (Lenning, Hill, Saunders, Solan, & Stokes, 2013).

1.4 Graduate employability and skills in the STEM context

Government and industry bodies strongly emphasise the importance of attracting and retaining more students in STEM disciplines. This goal is underpinned by the importance of STEM-related advances in driving innovation and expansion in current industries, the growth of new industries, improved productivity and living standards and hence a nation's economic growth, prosperity, global competitiveness and social well-being (Deloitte Access Economics, 2014; Office of the Chief Scientist, 2016; Wakeham, 2016). However, several Australian studies of STEM employers from the past five years have reported a shortage of STEM qualified applicants. A study undertaken on behalf of the Australian Office of the Chief Scientist (Deloitte Access Economics, 2014) found that over 20% of employers looking to hire STEM staff with or without experience reported a shortage of graduates and applicants. In a survey of 298 employers by the The Australian Industry Group (2018), many employers reported difficulty in hiring employees with STEM skills for professional (54% employers), sales (41% employers) and management (34% employers) occupations, with a growing proportion of employers reporting such difficulties compared with 2014 and 2016. Australian data also shows that over the period 2014 to 2019, STEM jobs have grown at approximately twice the rate of non-STEM jobs (19.7% to 10.2%) and that 74% of those working in STEM occupations have a Bachelor degree or higher compared with 22% people working in non-STEM occupations (Australian Government Department of Employment Skills Small and Family Business, 2020). Collectively, this data suggests that the overall demand for STEM qualified individuals in Australia is increasing, higher education is very important for those seeking a STEM-related career and there may be shortages of STEM qualified individuals for some roles. This seems at odds with the assertion of Norton (2016) of a highly competitive employment market for science graduates and that many science graduates are likely to experience difficulty in obtaining graduate level employment. This conflicting picture will be discussed in further detail below.

There is evidence to suggest that STEM graduates possess a transferable skill set that is highly desirable across all sectors to drive evidence-based decision making, productivity growth, innovation and leadership. As a result, it is suggested that STEM undergraduates should be educated about, encouraged and supported in pursuing employment both outside and within their discipline major. Rodrigues et al. (2007) argue "it is imperative that there are scientifically literate people in positions where important decisions are being made about the future of the society" and, referencing science graduate employment in professions outside their discipline, "a case can be made for attempting to increase the size of this group to ensure that scientifically literate people are at the decision-making levels of industry and government". Research indicates that businesses employing STEM-skilled staff are more productive and innovative than those who do not (Office of the Chief Scientist, 2016) and in a survey of over 1000 Australian employers, more than 82% of respondents "agreed that people

with STEM qualifications are valuable to the workplace, even when their qualification is not a prerequisite for the role" (Deloitte Access Economics, 2014).

In the latter study, the most valued skills that STEM graduates bring to an organisation (compared with non-STEM graduates) were seen to be their ability to learn on the job, critical thinking, complex and creative problem solving and innovation. In the Australian Office of the Chief Scientist (2016) report, STEM graduate strengths are noted as being quantitative skills, deep knowledge of a subject, creativity, problem solving, critical thinking and communication skills, in combination enabling STEM qualified individuals to "see and grasp opportunities".

In terms of skill weaknesses, the Deloitte Access Economics (2014) study concluded that STEM graduates' interpersonal skills were seen to be slightly lagging their non-STEM peers, which is significant, as the same study reported that this skill was the most important sought by employers in recruitment. In Sarkar et al. (2016), research amongst 53 Australian employers reported some dissatisfaction with commercial awareness, independent learning ability, problem solving, leadership skills and initiative of science graduates. In the same study, 167 science graduates were surveyed and over 40% of the graduates felt lacking in commercial awareness and leadership skills, and would liked to have further developed these skills in their undergraduate degree. Over 25% of these employed science graduates would also liked to have further developed their analytical and critical thinking skills, ICT and mathematical skills. In a study of 133 employed chemistry graduates in the UK (Hanson & Overton, 2010), over 40% would have liked to have further developed their oral presentation, report writing and experimental design skills at university, whilst over 25% would have liked further opportunity to develop their skills in instruments and analytical techniques, interpretation of data, numeracy/computation skills, problem solving, teamwork, independent learning and time management and organisational skills.

Overall, the skills and attributes reported as important or valuable in the workplace by a wide variety of employers of STEM graduates and employed science graduates themselves are; teamwork, analytical and critical thinking skills, problem solving, independent learning, verbal and written communication skills, organisation and time management, commercial or business awareness, flexibility/adaptability, leadership or management, interpersonal or social skills, creativity and innovation, computer or information technology skills and numeracy (Deloitte Access Economics, 2014; DEST; ACCI; BCA, 2002; Hanson & Overton, 2010; Lowden et al., 2011; Purcell, Atfield, Ball, & Elias, 2008; Sarkar et al., 2016). This list of important skills is common to the majority of employers and graduates surveyed in the literature just referenced, with three additional skills (discipline knowledge, practical/technical and research skills) valued by science and STEM industry employers and graduates. Work experience was also noted as highly valued by a majority of employers (Deloitte Access Economics, 2014; Lowden et al., 2011; Purcell et al., 2008). Complementing these conclusions, the recent The Australian Industry Group (2018) study reported that the most important factors considered by employers when recruiting graduates were relevant work experience, qualification and contribution to business culture, followed by enterprise and employability skills (such as problem solving and teamwork).

Conclusions from detailed data and research on the employment outcomes of STEM graduates are mixed. Despite the strong government and industry call for more STEM graduates, a significant proportion of science and maths graduates find it difficult to obtain relevant full-time employment, especially in the short term. In Australia, only 62.5% and 63.4% of science and mathematics graduates were employed full time four months after graduation in 2016 and 2019 respectively (Social Research Centre, 2019b). This was the lowest of all graduate study areas evaluated and well below the short-term graduate full-time employment average of 72.6-72.9%. Short term

employment prospects for engineering graduates are much higher (84.8% in 2019). Whilst medium term (three years after graduation) STEM graduate employment rates are better, (87.8% for science and mathematics and 95.4% for engineering) (Social Research Centre, 2019a), these medium term figures for science and maths graduates are still below the graduate average (90.1%) and well below those of teacher education, business, nursing and pharmacy graduates (93%-93.6%). Norton (2016) reported that life science graduates have the poorest outcomes of science graduates in Australia, with only 49% obtaining full time employment four months after graduation in 2015. He also concluded that maths and chemistry graduates "do better", but are still below the graduate average.

Australian government online internet vacancy data (Australian Government Labour Market Information Portal, 2019) indicates that the science professions that have grown the most in demand between 2007/2008 and 2018/2019 are actuaries, mathematics and statisticians (200%), life scientists (227%) and agricultural and forestry scientists (186%), although it must be noted that the latter is growing from a very low base. Environmental scientists have shown significant recent growth in demand, but are still at 64% of 2007/2008 demand levels. The demand for chemists and food and wine scientists and other natural and physical science professionals in 2018/19 were each half that of 2007/2008 with the former static and the latter growing. The demand for geologists and geophysicists in 2018/2019 was 14% of that in the height of the mining boom, but growing significantly. Overall, the largest numbers of science professional vacancies in 2018/2019 were for actuaries, mathematics and statisticians and environmental scientists (about two and a half times the number of job vacancies for chemists and food and wine scientists and three to three and a half times the number of vacancies for life scientists).

It appears that the Australian aggregate trend of STEM employment obscures a dynamic complex underlying reality related to specific disciplines and industries, with some graduates in disciplines such as chemistry, natural and physical science and particularly life sciences likely to experience difficulty in finding employment, whilst those from mathematics and environmental science in greater demand. Biological science graduates continue to experience the worst employment outcomes of all science graduates with four month post-graduation full time employment rates (at 53-57.7%) the third lowest of 45 Australian graduate study areas reported in 2017 and 2018 (only just ahead of music and creative arts graduates) and 18% lower than those from natural and physical science disciplines (Quality Indicators for Learning and Teaching (QILT), 2018). This helps explain why, although governments and some employers are calling broadly for students with STEM skills, Norton (2016) reported a highly competitive job market for science graduates, as supply still exceeds demand for a notable number of disciplines. Whilst aggregate demand is increasing with time, it currently still trails the rapid growth experienced in science higher education enrolments since 2007 (Australian Government Department of Education and Training, 2019), and is highly variable by discipline. USA and UK data indicate a similar situation. Heywood (2012) concluded that in the USA and UK, there are specific industry shortages, but not a comprehensive shortage of STEM workers. In their USA study, Xue and Larson (2015) agreed, citing examples of government and/or industry shortages in data scientists, software developers, cyber security and specific types of engineers (petroleum, nuclear, materials science and systems) and surpluses in biomedical, chemistry and physics PhDs. In a UK review of STEM graduate employability (Wakeham, 2016), employment outcomes for graduates from 16 STEM disciplines at six months and three and half years after graduation were investigated and categorised by three measures (unemployment rate, proportion of graduates in non-graduate roles and proportion of graduates on low salaries). Wakeham concluded that poor graduate employment outcomes were of significant concern for biological; earth, marine, environmental and agriculture; animal sciences and food sciences, with some concern also for biomedical and aerospace engineering and engineering design. Whilst other science

discipline graduates were not considered 'of concern' overall, below average employment outcomes were still observed for a number of other STEM disciplines. For example, chemistry and materials science graduates had above average unemployment rates, proportions in non-graduate roles and in low pay roles; mathematics graduates had above average to high proportions in non-graduate roles and above average proportions in low pay roles and physics and astronomy graduates had above average unemployment. Whilst overall unemployment statistics for most engineering graduates were good, electronic, electrical and chemical and process engineering graduates had high unemployment.

The Wakeham review (Wakeham, 2016) also found several other graduate characteristics were very important to employers, namely that they have had some work experience such as internships or placements and "a strong set of 'soft' or 'work ready' skills", with continued employer dissatisfaction with graduates about such 'soft' skills. Recommendations were made about the need to include additional opportunities for work experience during STEM degrees and to embed soft skills "more systematically and robustly" in the curriculum of STEM degrees. Wakeham also reported that there was evidence that some STEM graduates were experiencing "sub-optimal employment outcomes" because they didn't know how to connect the skills and knowledge developed during their degrees to the job market.

1.5 Recognition of the development and importance of transferable skills by science undergraduates

Recognition of their transferable skills is key for undergraduate students because, without it, they will be unable to highlight them in job applications or interviews. They will also be unlikely to have the confidence to embark on or perform well on tasks that require the transfer of specific skills in a work environment (Jackson, 2013). Likewise, valuing employability skills as being integral to workplace success is also crucial in order to motivate students to develop these skills and the ability to articulate them (Jackson, 2013).

Alan Finkel, Australia's Chief Scientist, stated that the future of Australia encompasses "a STEM-powered economy" and that "Our STEM community, and most of all our young people, should be given every encouragement to find new applications for their skills across the economy" (Office of the Chief Scientist, 2016, p. iii). Science graduates cannot find new applications for their skills without recognising they have developed them and that they add value to themselves, employers, the workplace and the economy at large.

Some studies have shown undergraduate science students do see the development of transferable skills as important. When such students are asked explicitly and quantitatively about development of named transferable skills, they rate them overall as both important (Leggett, Kinnear, Boyce, & Bennett, 2004; Matthews & Hodgson, 2012) and developed during the degree, but to varying levels depending on the specific skill (Matthews & Mercer-Mapstone, 2018; Varsavsky, Matthews, & Hodgson, 2014). There have also been significant differences reported in skill importance and development by science students of different year levels (Mercer-Mapstone & Matthews, 2015). In addition, some UK studies have concluded that students lack understanding of the skills employers are seeking from graduates (Tibby, 2012).

Research has suggested that students may not recognise employability skills developed within a degree without being prompted. Tomlinson's qualitative multi-faculty study asked final year undergraduates what is required to get a good job (Tomlinson, 2008). This study concluded that students feel employers are looking for personal skills and attributes in addition to a 'good quality'

degree, although the students cited extra-curricular activities as the vehicle for development of these, and students did not mention transferable skill development within their degree. Physics graduates in a recent Danish study (Nielsen & Holmegaard, 2016) reported that they found it difficult to identify and describe their own skills or competencies and that this impeded them significantly in the job market because it was hard to match themselves with job advertisement requirements.

Whittle and Eaton (2001) quoting an earlier study on biochemistry undergraduate students observed 'It has been shown in Science graduates that when skills are taught through an integrated, student-centred system, students may remain unaware of the opportunities offered by their course to improve their skills'. That is, when development of a skill is curriculum-embedded, students may not recognise its improvement without being directed to look for it. Indeed, in research conducted for an Australian multi-institution study on enhancing graduate employability in higher education (Bennett et al., 2015), it was reported that only half of students believed that their degree would provide them 'the skills and knowledge required to begin their future careers', with a lack of recognition by many students of the job-relevant skills developed in their degree.

In light of the above research, it could not be assumed that the employability skills that academic staff consider have been built into the science curriculum are recognised by students.

1.6 Recording and reflecting on skills to enhance recognition, articulation and employability

One approach for improving recognition of any learning (including transferable skill development) is reflection. Boud, Keogh, and Walker (2013), in their book on the role of reflection in learning, discuss at length the importance of reflection: that students need to be more actively engaged in their own learning, that "experience alone is not the key to learning" and that reflection enables students to turn experience into learning and to gain maximal benefit from situations in which they have been involved.

In addition to facilitating a consciousness and consolidation of learning, reflection offers other critical benefits. Both Saunders and Zuzel (2010) and Pretorius and Ford (2016) conclude that reflection also helps students to identify their strengths and weaknesses and think about and improve their learning and development. Other reflection benefits identified by students in the latter study were that it helped them to think about and understand their feelings and learn from mistakes.

Pretorius and Ford (2016) present the goals of reflection as self-discovery, growth and knowledge development, with 'reflection-in-action' occurring during an experience and 'reflection-on-action' occurring when reviewing an experience after completion. Ryan and Ryan (2015) discuss two levels of reflection; firstly, making sense of experiences, which they suggest may include personal reflections that don't necessarily have a specific or formal purpose and secondly, undertaking a critical reflection that involves identifying transformative learning that is used to improve future experiences. They state that the latter deeper form of reflection in an academic or professional context requires a specific stated purpose, links to assessment or professional development and evidence of learning, with the learner actively engaged in improving their learning and practice.

In the context of graduate employability, Yorke (2006) points out that providing employability enhancing experiences within the curriculum is insufficient and that employability will only increase if students learn from these experiences: "It is a mistake to assume that provision of experience, whether within higher education or without, is a sufficient condition for enhanced employability….

The curricular process may facilitate the development of prerequisites appropriate to employment, but does not guarantee it. Hence it is inappropriate to assume that students are highly employable on the basis of curricular provision alone: it may be a good harbinger but it is not an assurance of employability. Employability derives from the ways in which the student learns from his or her experiences".

Since the literature suggests that reflection is a very important method for learning from experience, reflecting on university curricular experiences could be a key way for undergraduates to increase recognition of their transferable skill development in preparation for employment. Indeed, reflection on university tasks and experiences was one of the major strategies recently suggested by science academics at several universities for enhancing development and recognition of generic employability skills in the curriculum (Sarkar et al., 2019).

Two of the models of employability discussed in Section 1.1 explicitly include reflection as a key element. The Knight and Yorke USEM model (Yorke & Knight, 2006) incorporates metacognition as one of its four 'pillars' with reflection explicitly mentioned as a necessary element for development of self-awareness, the ability to evaluate the performance of self and others, learn from these experiences and apply such learning. The Dacre Pool and Sewell (2007) CareerEDGE model for undergraduate employability development hinges on providing students with opportunities for "reflection on and evaluation of the learning" they have had in gaining skills, knowledge, understanding, attributes and experiences. They postulate that without such reflection and evaluation, students are unlikely to recognise the extent to which they have improved their employability and what they need to do to further enhance it and apply it. They suggest that through reflection and evaluation of their skills, learning and experiences, students' self-awareness, self-efficacy and self-confidence will grow in a number of important ways: their ability to act and continue to improve their employability skills, their understanding of how to apply their skills in a range of settings and circumstances, their ability to communicate their employability skills and attributes to potential employers and to manage their career and professional development.

Holmes (2013) argues for a "graduate identity" approach to employability. His perspective is that rather than simply possessing certain skills and attributes, graduates must develop a depth of identity and self-reality which includes the skills and attributes required to succeed in the workplace and that are sought by employers. He also states they must "develop ways of presenting [their] claim on the identity (or being a graduate worthy of employment) in such a way that it stands a good chance of being affirmed by those who make the selection decision on job applications." That is, students need to internalize their skill development through recognition and pinpointing instances that they can share with potential employers of when they have improved and exemplified the skills they identify with. Whilst he does not mention the concept of reflection explicitly, it would seem that reflecting on their university (and other) experiences in terms of their learning, skills and attributes would be likely to assist students to better develop the requisite graduate identity he proposes and identify examples they can use to evidence that identity. Development of such an ability to articulate transferable skills with examples is key to success in graduate recruitment (Harvey, 2005), with Evans and Richardson (2017) stating employers have reported "one of the key failings of graduates is a frequent inability to demonstrate their skills to best effect".

Reflection on experience, learning and skills has long been required of many undergraduate students in health sciences (Driessen, Van Tartwijk, Overeem, Vermunt, & Van Der Vleuten, 2005; Gordon, 2003; Koole et al., 2012) and education (Borko, Michalec, Timmons, & Siddle, 1997; LaBoskey, 1993; Yost, 2006) as a fundamental way of maximising student learning from their experiences, self-identifying strengths and weaknesses and facilitating identification of methods to improve performance and outcomes. It has also been fostered as a way of training students in the types of

self-evaluation and continuous learning that will be required to remain relevant, effective and successful throughout their professional lives.

Some research has been undertaken in medical education (the educating of doctors and other health professionals) to evaluate the impact of reflection on students. Gordon (2003) concluded that first year undergraduate medical students found reflection via a student portfolio as a 'useful' and 'worthwhile' part of their personal and professional development (PPD), with three quarters of participants identifying ways to improve through the reflective process. In terms of skill development, Koole et al. (2012) found a small but significant improvement in students' ability to solve problem medical cases as a result of overall engagement in reflective process during their training. However, there is a cautionary note in that Driessen et al. (2005) concluded that reflective practice is not always necessarily beneficial unless appropriately implemented. They suggested four essential elements for successful reflective use of portfolios in undergraduate medical education: appropriate portfolio structure and guidelines, relevant assessment procedure, sufficient new and relevant experiences to reflect on and teacher or mentor availability for coaching.

In an employability context, a pilot program at the University of Queensland (Reid, 2015) evaluated the impact of engaging undergraduates from a range of disciplines in reflection on their co-curricular or extracurricular study abroad, mentoring, undergraduate research or leadership activities. This program used a four step self-reflection model (Situation, Effect, Action, Learning (SEAL)) to help students link their experiences to employability development. Whilst half of participants found it initially difficult to connect an experience to employability, participating in the program was a positive experience which helped them recognise previously unidentified value from their experiences and "to better articulate the value of their experience to a potential employer".

Despite prevalent practice and evidence of its benefits in other disciplines, encouraging reflection by science students on their learning and skill development is far less common. Whilst some research has been undertaken into the impact of reflection on secondary school science students, the impact of transferable skills reflection on science undergraduates has received little attention to date. One study (Taylor, Rogers, & Veal, 2009) documents student self-reflection on laboratory skills after being videotaped performing a laboratory exercise, with subsequent notable improvement in the relevant practical skills. In a biosciences context (Parry, Walsh, Larsen, & Hogan, 2012), a "critical incident report" was introduced to engage a small group of students from a second year laboratory skills course in a semi-structured reflection on their practical skill development. In this study, students initially did not understand what reflection was, were unsure of its value and did not see its relevance in the practical laboratory context. They were also predominantly focused on marks. At the end of the course, they felt reflection may be valuable if included at the end of the session, especially as a group discussion.

Another recent study on a small pilot program of student volunteers (Rowland et al., 2019) explored the use of reflection and 'active learning' workshop experiences and discussions to help science students recognise and articulate their transferable skills gained from extracurricular (volunteer or paid work) experiences. One of the goals of the program was to help students make connections from their volunteer or work experience to skills that could be applied in future science graduate jobs. Through self-reflection, participants were able to identify their skills strengths and articulate skills gained from past work experiences from which they previously saw little relevance. The authors recommended the program be scaled up and offered to all science students as a valuable form of WIL and a much more scalable alternative to placements.

A few studies have been identified which have implemented a skills reflection element in engineering courses. Engineering students in the University of Northampton, England were surveyed about their perceptions of skills required by graduates in their field and their ability to provide evidence and examples of their skills (Duncan, 2010). A vast majority reported that they would like assistance in becoming more self-aware and in presenting themselves effectively in job applications. In response, an undergraduate student Professional Development Portfolio (PDP) was created that connected study and workplace skills and preparation for employment, including asking students to collect and document a series of examples that showed evidence of transferable skills and articulate them to meet job/employer requirements. Student feedback was very positive, indicating significant gains in "becoming more self aware, evidencing specific transferable skills and helping to develop self-presentation strategies".

Kaider and Shi (2011) report on the introduction of reflective practice regarding skills and competencies required of graduate engineers, as an assessed task in a unit undertaken by engineering students at an Australian university. Reflection was included because of the considerable benefits to learning it can provide, as identified by the authors from the literature. The aim was to assist students to identify skill weaknesses and actions they could take to improve. Students also completed a skills self-audit at the start and end of the semester. Initial analysis of the skills ratings and reflections provided by the students led the authors to conclude that some students tended to be more realistic and thoughtful in their reflections than in their skills self-rating. It was suggested that guided, open-ended reflection was perhaps a more accurate and valuable practice than an isolated skills rating exercise because although the latter showed value in terms of raising awareness of key skills, it was not as successful for identifying deficiencies.

As well as enhancing learning and the ability to articulate and evidence their skills, potential benefits to students of involvement in skill identification, recording and articulation could include an increase in early engagement with career planning and preparation (Choate, Green, Cran, Macaulay, & Etheve, 2016), with a related increase in drive to complete their degree, and consequent improvement in retention (Willcoxson et al., 2011). Encouraging students to identify and articulate the employability skills gained from course-embedded tasks may also increase student motivation and satisfaction and potentially also achievement, due to greater awareness of the value of the course work they are undertaking, as Jackson (2013) referencing Biggs (2003), states "theory strongly suggests effective learning requires a clear understanding of the value of presented material and associated activities".

No research on the impact on higher education science students of reflecting on transferable skills developed through the curriculum has been identified to date. This is despite the fact that the key activity of skill reflection, articulation and application is emphasized by Lowden et al. (2011), as one of the four main attributes sought by employers from graduates i.e. the "ability to reflect on their experience, make connections and 'tell employers their story' – of how all their university experience has contributed to their overall learning and recognising/being aware of how this learning is transferable to other contexts."

1.7 Badging to enhance the recognition of skills

Displaying skills badges is a potentially valuable approach for enhancing the recognition of skills by visually identifying in-curriculum skill development opportunities on relevant tasks and resources.

Lowden et al. (2011) investigated employers' perceptions of the employability skills of new graduates and concluded that "Universities need to reflect the promotion of employability skills and attributes in their mission statements, learning and teaching strategies, course frameworks, strategic documents and practical guidance." Badging of employability skills in the curriculum is one strategy science faculties could use to promote and highlight employability skills.

Saunders and Zuzel (2010) conclude from their study of undergraduates, graduates and employers of biomolecular science students, that explicit links need to be made between the academic curriculum and employability. Badging of skills developed by tasks within the science curriculum could be a way of making such links.

'Digital badging' has been a topic of interest in education research in recent years. However, the research has focused almost exclusively around digital badges as a form of micro-credential, represented by a digital image, for recognising a student's proficiency in a particular skill, knowledge or ability (Devedžić et al., 2015; LaMagna, 2017). One of the advantages of digital badges is that they contain embedded metadata and can be linked to specific evidence of the individual's competency including details of the assessment task(s) that led to awarding of the badge. This data is much more transparent and potentially much more detailed than an academic transcript (Casilli & Hickey, 2016; LaMagna, 2017).

A review of the literature on digital badges (Frederiksen, 2013) concluded that there has been a lot of attention on the topic, but there is a lack of research in this area, with articles to that date mainly describing the idea, the process and potential benefits and issues.

For example, Bowen and Thomas (2014) outline a system of badging used at Purdue University, with the aim of recognising cross-curricula skill development and the wide range of skills students gain at university beyond grades. Dale Whittaker, Purdue's vice provost for undergraduate academic affairs stated:

> "There are things we want our students to know and be able to do that span curricula and span classes, which we call embedded outcomes. Badges would allow us to track the development of those embedded outcomes." (p. 22)

Purdue were focused on the implementation of digital badges using Mozilla software, which links badges to supporting information, or metadata, including who issued the badge, when it was issued and relevant evidence of skill development. Bowen and Thomas discuss the benefits of such a badging system including that students will then be able to use this evidence in their CVs, job interviews and to communicate with employers.

Hurst (2015) and Gibson, Ostashewski, Flintoff, Grant, and Knight (2015) describe how some designers of digital badges use principles from 'gaming' to motivate and engage students. That is, another aim of badges can be to encourage learners to complete learning activities and spend more time on a task by providing a badge as an incentive or reward. Sometimes 'leaderboards' and points are also associated with the badges so learners are motivated by competing with others or striving to better their 'score'.

In one case study (Kim, 2014), a professor introduced badges in his course to "communicate student competency beyond the grade or transcript. In addition to the normal complement of lectures and discussion and exams in the course, students also learn how to use media analysis software and produce digital scholarship. But you would never know that from the course title or grades or transcript information." This aim reflects another use of badges; to recognise specific significant additional skills students have gained through a completed academic unit, that aren't represented

by their grade or assessment. Gibson et al. (2015) refer to this use of badges as to “summarise achievement and signal accomplishment”.

Several of these approaches are reflected in a recent chemistry setting (Hensiek et al., 2016) where students were awarded digital badges for demonstrating ability in specific laboratory skills (measuring the volume of liquids using a burette and making a solution using a volumetric flask). Research on outcomes via pre- and post- survey questions and exam assessment led to the conclusion that the badges and the process undertaken to gain them led to positive outcomes for student learning of the two skills and that a digital badging process can be used to enhance students’ hands-on skills. Likewise, Seery et al. (2017) report successfully using digital badges to record and recognise student skills in titrations, distillations and standard solution preparation, with follow up research planned on student interest in badges and their motivational impact.

Each of the above examples use badges either as an award or reward to represent that a skill has been demonstrated or gained. Whilst this approach offers many potential benefits, it can also require significant resourcing. A set of skill metrics (transferable or technical) must be clearly defined, allowing for expansion as the breadth of badges develops. Ideally, skills metrics should be agreed and available across an institution to maintain transparency, consistency and comparability. Opportunities must be identified or created to measure each skill and it must be agreed who and how they will observe the skill and what evidence will be collected and required for achievement. Other necessary decisions include whether each badge will have different skill levels, whether the assessment will be based on an individual or group task and how to scaffold skill development prior to assessment (Casilli & Hickey, 2016; Devedžić et al., 2015).

By contrast, the concept of simply using skills badges as a transparent way of labelling a course or task with icons representing the skills it is designed to develop has received very little attention in the literature. This approach could be considered a type of transparent curriculum design in which the purposes of curriculum tasks are made more obvious to students, which may lead to improved learning outcomes (Winkelmes, 2013).

The closest comparison is with studies that have looked at mapping skills to courses and tasks within the curriculum and publicising the skills developed within course content descriptions. For example, Robley, Whittle, and Murdoch-Eaton (2005) outline how an undergraduate medical curriculum at a UK university was mapped against national benchmarks, learning outcomes, assessment and delivery of embedded transferable skills by surveying students and staff and reviewing documentation. Their key aims were to draw attention to skills delivery for those developing the curriculum and to skills development for students. However, they commented that the complexity of these types of multi-faceted curricula maps can limit their use by some stakeholders, with electronic delivery with many embedded links being the only viable way of delivering and accessing all of the interrelated information. This study points out that by enabling student access to information about skill development throughout the curriculum, students are able to self-assess their generic skills, reflect on current and prior learning and select future learning units to meet their skill ‘gaps’.

Fallows and Steven (2000) outline a university wide initiative to make transferable skills evident throughout the curriculum and bring them to the attention of students. Module information, course booklets and learning outcomes were all edited to include skill provision, and skill development was highlighted in lectures, seminars and assignments. Although the report was written too soon after implementation to be able to track whether it had impacted employment rates, staff reported an overall lift in student performance. “Staff have noticed a general upward lift in performance after implementing the modified curriculum focusing on communicating and delivering more

employability skills." The reason for this improvement was unknown, but they suggested it may be related to an increased inherent focus on student responsibility for their own development and employability. This study also reported that the impact of the skills initiative appeared to be higher amongst undergraduates studying humanities subjects, who tended to realise they will need to rely on the generic skills developed at university in later employment, rather than their specialist subject knowledge. By contrast, students enrolled in more vocationally-focused degrees seemed to have greater expectations of obtaining employment on graduation and were much slower to recognise the generic skills developed in the curriculum. This observation reinforces the point that students must also perceive the value and future application of the skills being developed in order to significantly benefit from their provision and communication.

Each of these studies highlights that drawing students' attention to employability skill development during their undergraduate studies has the potential to positively impact students. However, none of these studies have used a 'badging' technique for highlighting curriculum embedded skills, and, prior to this study, the impact of using such a technique was unknown.

1.8 Aims and research questions

The broad aims of the project were to obtain an understanding of how well science undergraduates recognise and value the transferable skills they are developing during their degree and to investigate whether engaging students in reflecting on curriculum-related skill development and displaying skills badges on student-facing curriculum materials helps students recognise and articulate their transferable skills.

The two research questions addressed were:

1. Do science undergraduates at Monash University and the University of Warwick recognise they are developing transferable skills during their degree and value such skills?
2. Does engaging science students in reflection on their degree experiences and/or displaying skills badges on curriculum materials increase students' ability to recognise and articulate their transferable skill development?

The University of Warwick was included to enhance the validity and potential benefits of the study by exploring whether the outcomes applied in a different country and university context.

The project was divided into four elements, each of which addressed different aspects of these research questions, as follows:

Element 1. Recognition of transferable skill development and their importance by science undergraduates

- Which transferable skills do science undergraduates studying chemistry:
    - recognise they are developing during their degree?
    - wish to further develop during their degree?
    - believe employers are looking for, from graduates?
- Do the skills identified vary significantly by university (Australian vs UK), year level or gender?

Element 2. The impact of reflecting on skill development experiences experienced within the science curriculum, investigated through a voluntary semester-long program of recording and reflecting on skills.

- Does reflection help science students to better recognise skills developed through the curriculum, enhance their ability to articulate their skills and/or benefit them in other ways?

Element 3. The impact of badging employability skill development opportunities in the science curriculum

- Does displaying skills badges on curriculum materials lead to enhanced student recognition of skill development opportunities?
- Do the badges have other impacts on students and teaching staff?

Element 4. The impact of incorporating skills reflection into the undergraduate chemistry laboratory curriculum in combination with displaying skills badges

- Does embedding reflection in the presence of skills badges help science students recognise skills developed through the curriculum, enhance their ability to articulate their skills and/or benefit them in other ways?

2 Methodology and Research Framework

This chapter outlines the theoretical framework that underpins this research and the overall research design and ethics approval. The two participating institutions are described, as well as the overall approach to data analysis. The details for each of the four main parts of the study are then presented, including research instruments, participants, data collection and data analysis.

2.1 Qualitative research theoretical framework

The theoretical framework that underpins this study is constructivism, which can be defined as follows: "Constructivism focuses on individuals making sense of their experiences" (Patton, 2002) and "The aim of constructivism is 'understanding and reconstruction'"(Bodner & Orgill, 2007; Lincoln & Guba, 2000). Constructivism suggests that people actively construct knowledge in their minds, rather than simply 'acquiring' it. It also suggests that learning is an iterative process through which people create a mental framework that helps them make sense of their experiences and then adjust and refine that framework continually based on further experiences and their evaluation of them (Bodner & Orgill, 2007). The constructed knowledge is the way people "organise" and understand their experiences, through constructing "concepts and contexts" (Flick, 2006).

Research based on constructivism recognises that, in many instances, the only way to understand the meaning behind an action or response is to ask the person involved. In a qualitative research process underpinned by constructivism, the researcher "tries to see the world from the perspective of the individual whose sense-making or meaning-making is being studied" (Bodner & Orgill, 2007) and tries to draw on participants' views as much as possible when interpreting the research (Creswell, 2009).

The form of constructivism that is particularly pertinent to this research is social constructivism, as it acknowledges that learning most often occurs in a social setting (involving others), and is influenced by cultural and social factors associated with the learning context. It seeks to understand how people make sense of "the world in which they live and work" (Creswell & Poth, 2017) and recognises that these individuals' views are not developed in isolation, but are influenced by their interactions with others and the situations they experience. It emphasises that social interaction plays a very important role in how people construct their knowledge, including the language used (Flick, 2006).

Social constructivism underpins both the interventions implemented in this study and the qualitative research process that investigates the impact of these interventions. Prior to their involvement in this study, the student and staff participants will have already constructed some perceptions of employability – their views of the skills, qualities, achievements and experiences that may be required of them or will assist them to be successful in the job application process and in the workplace itself. They will also have constructed some perceptions and beliefs about their own skills and abilities. Participants' own education, employment experiences and social contexts (what they have heard from and observed about others) will have been influential in the way they have constructed this 'knowledge'. The hypothesis on which this study is based is that the skills badges and skills reflection interventions investigated could help students to construct a wider and deeper understanding of the employability skills they have developed through their higher education.

Social constructivism recognises that each person creates multiple and complex meanings from their experiences and tries to unpack the variety of views rather than simplifying it narrowly. Researchers

operating in a social constructivist framework (such as this study) use open-ended questions so that participants can freely communicate their thoughts and perspectives. They also collect data within the relevant social context of the participants in order to understand that setting and how it relates to the participants' views (Creswell, 2009).

In this study, the social setting is science undergraduate education. All research was carried out in university science settings relevant to the curriculum experiences about which the student and staff participants were responding. The qualitative research undertaken provided opportunities for students and staff to openly share their perceptions of the skills students had the opportunity to develop through the curriculum. It also provided opportunities for them to communicate the diversity of reactions they had to the interventions and the reasons for these reactions in order to determine what knowledge they created as a result of their involvement with the interventions.

2.2 Research design

This study used an exploratory mixed methods design, incorporating both qualitative and quantitative research techniques (Creswell, 2009).

Quantitative research was used to explore the experiences and attitudes of a large number of participants through a survey designed to address the research questions, using a worded or numeric scale. The data can then be analysed statistically to determine any changes in attitudes or outcomes before and after an educational intervention and/or to what extent the findings may apply across different demographic groups, cohorts and institutions (Choy, 2014; Creswell, 2009).

Qualitative research was undertaken in this study through open-ended survey questions, focus group discussions and interviews. This type of research allows for exploration of participants' individual experiences and the meaning they ascribe to them and allows for the complexities of a situation to be investigated. In this study, qualitative research was conducted face-to-face in the (university) context relevant to the topic and the purpose was to determine the sense participants made of their experiences (Creswell & Poth 2007). The intention was also to develop a well-rounded understanding of the issue being researched, incorporating the perceptions and viewpoints of all participants involved, including students and teaching staff.

Mixed methods research as applied in this study, incorporated both qualitative and quantitative elements concurrently and then used a process of triangulation to combine them in the data analysis process. This involved comparing and contrasting the results from different research sources to confirm insights and conclusions, as well as to improve the depth of knowledge obtained (Creswell, 2009; Flick, 2006).

The research methods used to explore each of the research questions are summarised in Table 2.1.

Table 2.1 The research methods used to explore the research questions

Project element	Research questions	Research methods
1. Recognition of transferable skill development and importance by science undergraduates	1.1 Which transferable skills do science undergraduates studying chemistry: a. recognise they are developing during their degree? b. wish to further develop during their degree? c. believe employers are looking for, from graduates? 1.2 Do the skills identified vary significantly by university (Australian vs UK), year level or gender?	*Qualitative research* • Large scale survey of students across two universities involving three open-ended questions and demographic questions
2. The impact of identifying and reflecting on skill development experiences from the science curriculum	2 Does reflection help science students better recognise skills developed through the curriculum, enhance their ability to articulate their skills and/or benefit them in other ways?	*Quantitative research* • Pre- and post-program survey of 60 participants who completed a semester-long skills reflection program *Qualitative research* • Audio recorded focus groups and interviews[a] of student participants in skills reflection program (mid-semester and end of semester) • Student reflections • Open-ended comments from participant surveys

3. The impact of badging employability skill development opportunities in the science curriculum	3.1 Does displaying skills badges on curriculum materials lead to enhanced student recognition of skill development opportunities?
	
	3.2 Do the badges have other impacts on students and teaching staff?
		Quantitative research
		• Surveys of students completing six units before displaying skills badges (pre-badging surveys)
		• Surveys of students completing nine units after displaying skills badges on curriculum materials for a semester (post-badging surveys)
		
		Qualitative research
		• Audio recorded focus groups and interviews[a] of:
		  ○ students completing six units before displaying skills badges
		  ○ students completing eight units post-badging
		  ○ teaching associates who had taught seven units in which skills badges were displayed
		• Open-ended comments from student post-badging surveys

Project element	Research questions	Research methods
4. The impact of incorporating skills reflection into the undergraduate chemistry laboratory curriculum in combination with displaying skills badges	4. Does embedding reflection in the presence of skills badges help science students recognise skills developed through the curriculum, enhance their ability to articulate their skills and/or benefit them in other ways?	*Quantitative research* • Surveys of students completing two units in which skills badges were displayed and students reflected on skills involved in laboratory tasks *Qualitative research* Audio recorded focus groups of: • students completing the above two units involving skills badges and skills reflections • teaching associates from the above two units involving skills badges and skills reflections

[a]Interviews were conducted when participants were unable to attend the scheduled focus group sessions.

2.3 Human research ethics approval and procedures

All research was approved by the Monash University Human Research Ethics Committee (MUHREC) under project 2018-0936-24529, as verified in Appendix 1. All surveys were optional and completed at students' discretion and all focus groups and interviews involved voluntary participation.

2.4 Participating institutions and participants

All research participants involved in this study were undergraduates or Teaching Associates (TAs) (staff employed on a part-time basis to teach in laboratories or workshops, sometimes also known as demonstrators or tutors) from either the Monash University Faculty of Science (Clayton campus) or the Department of Chemistry, Faculty of Science at the University of Warwick.

2.4.1 Monash University

Monash University is a large higher education and research institution based in Melbourne, Australia. It conducts undergraduate and postgraduate teaching and research across ten faculties and is part of the 'Group of Eight (Go8)' leading research-intensive universities in Australia. It is ranked the best university in Australia for chemistry (Academic Ranking of World Universities, 2020). It has four campuses in Australia (Clayton, Caulfield, Peninsula and Parkville) and two overseas campuses (Malaysia and China).

The total undergraduate and postgraduate enrolments in the Faculty of Science of the Monash University Clayton campus was 6,215 in 2017. Undergraduate science students at Monash University undertake a three year Bachelor of Science degree, a four year Bachelor of Science Advanced degree (which includes an integrated Honours year) or a four to five year double degree in combination with another faculty (*e.g*. Science/Arts, Science/Engineering, Science/Commerce, Science/Law etc). At the end of their third year, Bachelor of Science students may enrol in an additional Honours year (if they meet the grade requirements). The Honours year involves completion of an individual research project and thesis, in addition to course work.

Units are taught over one semester, with two semesters per academic year. In the first year, science undergraduates study four different science units in each semester. At the Clayton campus, these may include core units from chemistry, physics, astronomy, biology, biomedical science, maths, earth science, environmental science, atmospheric science, computer science and/or psychology. After the first year, students specialise in at least one science major from 25 options across five broad areas (biological and life sciences, biomedical and behavioural sciences, earth and environmental sciences, mathematical and computational sciences and physical and chemical sciences). Students may also complete a second major or a minor from any of the same disciplines. In terms of students studying chemistry, over 1000 undergraduates take a first year chemistry unit, approximately 250-300 study chemistry at second year and 150 at third year.

2.4.1.1 Monash University science degree expected skill outcomes

All graduates of a Monash University science degree are expected to achieve seven specific outcomes related to their knowledge and skills (Monash University, 2018). These are the attainment of discipline specific knowledge and skills; an understanding of the importance of science; the ability to generate and apply scientific knowledge and to develop solutions to problems; the ability to collect, analyse and interpret data using appropriate mathematical/statistical tools; the ability to communicate to a range of audiences through various formats; the ability to work and learn both

independently and collaboratively and to behave ethically, always showing responsibility to self and others. These outcomes are aligned with the Monash University graduate attributes which specify that all graduates should be responsible, act ethically, be good communicators, innovative problem-solvers, creative, critical thinkers, able to apply research skills to a range of challenges and engage globally with good cross-cultural competence (Monash University, 2019).

2.4.2 University of Warwick

The University of Warwick is a large higher education and research institution with one campus in Coventry, UK. It is a member of the Russell Group of elite research-intensive universities. Its undergraduate and postgraduate teaching and research occurs across three faculties (Arts; Social Sciences and Science, Engineering and Medicine).

The University of Warwick School of Chemistry is in the top ten of all major league tables for higher education chemistry in the UK. Undergraduates undertake either a three year Bachelor of Science degree focused on chemistry or four year Master in Chemistry degree. The Master in Chemistry degree may include an integrated industrial year or study overseas and the fourth year is dedicated to an academic research project.

Within the University of Warwick chemistry degrees, modules are taught on a year-long basis, with three terms per academic year and laboratory teaching occurring in the first two terms in the first and second years. In their third year, students complete all their laboratory work in a month long intensive block at the beginning of the third term.

All modules studied in the Warwick chemistry degrees have a chemistry focus, with all modules at first and second year being compulsory. Total first year enrolments in a Warwick chemistry degree each year are approximately 150 (range 120-180) and this remains relatively consistent across each year of the degree.

2.4.2.1 University of Warwick chemistry degree expected skill outcomes

Over the relevant period of this study (2016-2018), the University of Warwick did not have an institutional policy on graduate skills or attributes. These were developed by individual departments. The Warwick chemistry department specifies target skills for students within the principle aims and learning outcomes for each module (University of Warwick, 2018). During this study, the target skills specified in the first year included practical/laboratory skills, data processing/analysis, software/IT, problem solving and numeracy. In the second and third year, the following additional skills were specified: report writing, experiment design, information retrieval, teamwork, communication (including oral presentation), commercial awareness and job/career skills.

2.5 Conducting focus groups and interviews

The entire student population under study for a particular project element (*e.g*. from a particular unit) were invited to join a focus group discussion via an announcement on the Learning Management System (LMS) and/or face-to-face invitations during workshops or laboratory sessions. All Teaching Associates (TAs) involved in teaching the relevant unit/module were invited to participate in a focus group discussion by an email invitation. If multiple TAs volunteered to participate but could not attend at similar times, individual TAs participated in an interview. Likewise, if students had volunteered to participate in focus group discussions but could not attend any of the scheduled sessions, an interview was conducted. Both students and staff were offered refreshments to thank them for their participation.

Focus groups and interviews were conducted according to established protocols (Flick, 2006; Silverman, 2013). Before commencing, participants were given an explanatory statement to read and a consent form to sign, to ensure they understood the topic of the discussion and how the data would be used and consented to the discussion being recorded and analysed. It was also explained verbally to participants how the data would be analysed and used and that it was important that each participant was honest when expressing their thoughts and ideas as the data would only be valuable if it reflected their true thoughts, feelings and experiences.

In focus groups, all participants were invited to contribute to the discussion although it was explained that each participant was not expected to have an answer for every question. Just before commencing the discussion or interview, participants were asked if they had any questions and if so, these were addressed.

To help the focus group participants 'warm up' and feel more comfortable (Flick, 2006), they were invited to share their names, and at both interviews and focus groups, an initial question was asked that was expected to be fairly easy to respond to. Throughout the focus group or interview, the facilitator asked a number of previously developed questions, whilst trying not to 'lead' or bias the responses or ensuing discussion (Silverman, 2013). At the end of the interview or focus group, participants were thanked for their time and for sharing their thoughts and ideas.

2.6 Approach to data analysis

Paper-based survey instruments were developed individually for each of the four research elements of the project. These are discussed in detail in the individual methodology sections for each element, 2.7-2.10. The overall approach taken to analysing the quantitative data sets generated using the survey instruments and the qualitative data sets generated from focus groups and interviews was consistent throughout.

2.6.1 Analysis of quantitative survey data

All quantitative data instruments used in this study were paper-based surveys. After administering and collecting each survey, data were transcribed into an Excel spreadsheet with one row per respondent and a column for the responses to each question. The data were then summarised into tables and explored graphically to look for trends or relationships between variables.

In order to compare responses by different demographics groups (*e.g.* university, gender or university year level) or pre- or post-intervention, the data were imported into SPSS statistical analysis software.

Most survey data generated in this study were either nominal/categorical (*e.g.* respondents chose a particular named category or demographic data such as gender or student type) or ordinal/rank-order (*e.g.* respondents answered using an ordered worded scale). Non-parametric statistical techniques were used to analyse this data, as per standard statistical practice for these two data types (Sheskin, 2003). Such data types cannot generally satisfy the normal distribution assumption underlying the application of parametric statistics (Pallant, 2016).

The non-parametric statistical tests applied in this study were:

- Chi-square test for independence and Fisher's Exact test – used to evaluate whether two categorical variables are independent of one another *i.e*. have no correlation between them (null hypothesis) or whether there is a relationship or correlation between them (alternative

hypothesis) (Pallant, 2016; Sheskin, 2003). *e.g.* Is there a relationship between gender and recognition of teamwork development? *i.e.* Do males recognise that they have developed teamwork to a different extent than females? The assumptions for the chi-square test include that the groups to be compared must be independent (with no common members); each sample has been randomly selected from the relevant group population and that the 'minimum expected cell count is five' *i.e.* the number of respondents in all sub-groups corresponding to each level of the categorical variables, must be at least five. When the latter criterion is violated, the Fisher's Exact test is used (Sheskin, 2003).

- Mann-Whitney *U* test – used to evaluate whether two independent groups differ in their responses on a particular ordinal measure *e.g.* Do students who have experienced an educational intervention rate their opportunity to develop their numeracy skills differently compared with students who have not experienced the intervention? This test is the non-parametric equivalent to the independent samples *t*-test. It converts responses to ranks and then compares the medians of the two groups. The null hypothesis is that the two groups have the same median values and the alternative hypothesis is that the two groups have different median values. The assumptions for this test are that the groups to be compared are independent and that each sample has been randomly selected from the relevant group population (Sheskin, 2003).
- Wilcoxon signed rank test (also known as the Wilcoxon matched pairs signed rank test) – used to evaluate whether two dependent groups differ in their responses on a particular measure. It is used when the same participants are measured at two different time points or under two sets of conditions. *e.g.* Do students who have experienced an educational program rate their confidence differently after the program compared with how they rated it before the program? It is the non-parametric equivalent to the dependent samples *t*-test. It calculates the difference in response value for matched pairs by subtracting a participant's response under condition/time 1 from the same participant's response under condition/time 2. The null hypothesis is that the median of the difference scores is zero (Sheskin, 2003).
- The Kruskal-Wallis test (the non-parametric alternative to a one-way ANOVA) – used to evaluate whether there are differences in ordinal data between three or more groups (such as university year levels one, two and three). It is an extension of the Mann-Whitney *U* test used when there are three or more independent samples to compare. If the result is significant, it can be concluded that there is a significant difference in the medians of at least two of the groups. Like the Mann-Whitney *U* test, the assumptions are that the groups to be compared are independent and each sample has been randomly selected from the group population (Pallant, 2016; Sheskin, 2003).
- The Spearman rank order correlation test - used to evaluate the extent of relationship between two variables (such as between students' responses to whether their TA explained the purpose of writing skills reflections and how much writing skills reflections helped them in a particular way). It is the non-parametric equivalent to the Pearson product-moment correlation test. It assumes that the sample under consideration has been randomly selected from the relevant population and is calculated using the set of ordered ranks for each variable. The test returns a Spearman rank-order correlation coefficient (r_s) in the range -1 to 1. The absolute value of r_s is an indication of the strength of the relationship between the two variables. The closer r_s is to 0, the weaker the relationship and the closer to +1 or -1, the stronger the relationship, with the sign indicating the direction of the relationship. A positive

correlation indicates that when one variable increases, the other variable also tends to increase and a negative correlation indicates that when one variable increases, the other tends to decrease. The null hypothesis associated with this test is that in the underlying population of interest, the correlation between the ranks of the two variables is zero. If the null hypothesis is rejected, the correlation is significantly different from zero and the correlation coefficient may be interpreted as: small if its magnitude is between 0.1 and 0.29, medium if it is between 0.3 and 0.49 and large if it is greater than or equal to 0.5 (Pallant, 2016; Sheskin, 2003).

The parametric statistical tests applied in this study were:

- *t*-test - used to compare the mean scores of two different groups of respondents when respondent choices are based on a numerical rather than a categorical scale. When the two groups are the same participants responding on two different occasions (*e.g.* before and after an intervention), a paired-sample *t*-test is used to evaluate whether there is a significant difference in the mean value of the second set of responses compared with the first set of responses (Pallant, 2016).

For each survey conducted in this study, multiple data measures were collected and multiple statistical tests were carried out. Where multiple statistical tests are completed on the same overall data set, there is a significantly increased chance of a Type 1 error occurring *i.e.* of rejecting the null hypothesis and concluding there is a relationship or difference between groups when there is not. To help overcome this risk, a reduced level of significance was applied to each survey data set, according to the modified False Discovery Rate method developed by Benjamini and Yekutieli (2001) and elaborated by Narum (2006). This method reduces the chance of a Type 1 error whilst maintaining sufficient statistical power to detect true differences. The precise level of significance applied to each survey data set was selected from the table provided by Narum (2006) according to the total number of statistical tests carried out on each data set.

Effect size is used to evaluate the magnitude of a detected statistically significant difference. For the chi-square test and Fisher's exact test, Cramer's *V* is a measure of effect size. The interpretation of effect size is dependent on the number of degrees of freedom (*DF*) for the variables under consideration, as follows: *DF* = (n1-1) x (n2-1) where n1 and n2 are the number of levels of each variable. The interpretation of Cramer's V applied was as per Kim (2017). *e.g.* Where both variables have two levels, the number of degrees of freedom is one and a Cramer's *V* of 0.1 is considered small, 0.3 is considered medium and 0.5 large. Where one variable has three levels and the other two, the number of degrees of freedom is two and a Cramer's *V* of 0.07 is considered small, 0.21 is considered medium and 0.35 large. Where degrees of freedom are five or above, a Cramer's V of 0.04 is considered small, 0.13 is considered medium and 0.22 large.

For the Mann-Whitney *U* test and Wilcoxon signed rank test, effect size is calculated by dividing the *Z*-score by the square root of the total number of respondents from both samples (Effect size = *r*= *Z*/sqrt(n)). The interpretation of this effect size was carried out according to Lenhard and Lenhard (2016) *i.e.* If the calculated effect size is between 0.1 and 0.2, it is referred to as 'small', with those between 0.2 and 0.3 referred to as 'intermediate' or 'medium' and those greater than 0.3 referred to as 'large'.

2.6.2 Analysis of qualitative data

All focus groups and interviews (summarised in Table 2.2) were audio recorded (with consent) and then transcribed into Microsoft Word.

Table 2.2. Summary of focus groups and interviews conducted

Project element	Participant type	Number of focus groups conducted	Number of interviews conducted	Total number of participants (focus groups & interviews)
2. The impact of identifying and reflecting on skill development experiences from the science curriculum	Student	14	2	60
3. The impact of badging employability skill development opportunities in the science curriculum	Student	18 (8 pre-badging, 10 post-badging)	5 (2 pre-badging, 3 post-badging)	103
	Teaching associate	3 (post-badging)	5 (post-badging)	17
4. The impact of incorporating skills reflection into the undergraduate chemistry laboratory curriculum in combination with displaying skills badges	Student	6	-	29
	Teaching associate	3	-	8

Transcriptions were subjected to thematic analysis in order to identify important concepts, participant points of view, or 'shared meaning' that arise from the qualitative data (Braun, Clarke, Hayfield, & Terry, 2019). Themes can be defined as the 'shared meaning' of excerpts of text that are grouped together through being similar or connected to each other (Buetow, 2010). The thematic analysis process followed was that outlined by Creswell (2009).

After importing the transcripts into NVivo 11 or NVivo 12 qualitative analysis software, a third to a half of the transcripts were studied in detail and then an initial set of themes was identified as they emerged from the data. Sub-themes were also identified wherever distinct elements arose from the data under specific themes. Further transcripts were then reviewed until theme 'saturation' was reached *i.e.* when no new themes were identified. Each themes and sub-theme was then assigned a unique identifying code. Half of the transcripts were then coded in detail *i.e.* any small sections of the text identified to be relevant or indicative of a particular theme or sub-theme were highlighted and linked to the theme/sub-theme code using the software.

Two transcripts were then provided to two other chemistry education researchers and they were asked to code the transcripts using the provided themes and codes, and to suggest any additional themes if they thought any were missing. Their feedback was then discussed and used to refine the theme list as necessary *e.g.* In some instances, several themes or sub-themes were combined into a more over-arching theme, the names or descriptions of some themes were adjusted for greater clarity or a new sub-theme was added. After these final theme adjustments were made, and a subsequent round of coding using the final themes and codes was completed, the level of agreement between coders was calculated as a percentage to give an 'inter-rater reliability' according to the 'coding reliability' method described by Braun et al. (2019).

After completing the above inter-coder comparison, the remaining transcripts were coded by the author using the agreed final theme list.

2.7 Recognition of transferable skill development and the importance of transferable skills by science undergraduates

Science undergraduates' recognition of their transferable skill development and the importance of transferable skills was investigated using a qualitative (open-ended) survey administered to Monash University and University of Warwick students. A copy of the survey is provided in Appendix 2.

2.7.1 Survey instrument

The research instrument was designed to ascertain student views of the development of their skills related to the curriculum, the skills that they valued and those they believed employers valued. Three open-ended questions were developed, so that students were not prompted by a pre-defined list of skills. The questions were:

- In addition to developing detailed subject knowledge, what skills do you think you've developed so far in your degree?
- What skills would you like to develop during the remainder of your degree? (students prior to final year)

  OR
  What skills would you like to have developed to a greater extent during your degree? (third/final year students)
- What do you think are the key skills employers are looking for, from graduates?

Students were invited to list up to five skills for each question, with five dot points provided under each question, so that students recognised they could write multiple skills, but were not overwhelmed by the expectation of writing a long list.

Students were also asked four demographic questions: gender, whether they were a local or international student, their degree type (*e.g*. science, science/engineering, science/arts etc) and university year level.

2.7.2 Data collection and participants

The single page survey was administered in hard copy form to science students across three campuses.

At Monash University Clayton campus, students studying a chemistry unit at first to third year levels were surveyed. Students completed the survey in the final two weeks of the academic year (October 2016) in a range of contexts (tutorials, laboratory classes, presentation preparation or presentation delivery sessions). 50% of the first year, 64% of the second year and 56% of the third year chemistry cohorts completed the survey.

At the University of Warwick, first and second year students were surveyed towards the end of term 1 (end November 2016). Third year students were surveyed at the beginning of the final month of the academic year (end April 2017). All the students were surveyed during a break in laboratory classes. 40% of the first year, 39% of the second year and 74% of the third year cohorts completed the survey.

The demographics of the survey participants from each institution are shown in Table 2.3 and are representative of the relevant chemistry undergraduate cohorts.

Table 2.3. Demographics of skills survey participants

University	Demographic	Number of responses	% sample
Monash Clayton campus	**Total**	**774**	
	Gender:		
	Male	347	45%
	Female	412	53%
	Other/rather not say	15	2%
	Student type:		
	Local/domestic	712	92%
	International	60	8%
	Unspecified	2	
	Degree:		
	Science	422	55%
	Biomedical Science	101	13%
	Science double degree	234	30%
	Other	14	2%
	Degree year level:		
	One	475	61%
	Two	217	28%
	Three*	82	11%
Warwick	**Total**	**216**	
	Gender:		
	Male	118	55%
	Female	97	45%
	Unspecified	1	
	Student type:		
	Local/domestic	194	90%
	International	21	10%
	Unspecified	1	
	Degree year level:		
	One	64	30%
	Two	71	33%
	Three	81	37%

*Monash year three includes science double degree students in third year or higher

2.7.3 Data analysis

Survey responses were transcribed verbatim into Excel, with one spreadsheet created for each of the three survey questions. The three Excel spreadsheets were uploaded into NVIVO 11 qualitative analysis software as three individual data sets.

Students tended to be succinct in responding to the skills questions. After reviewing a subset of the data from each question at each university and year level, a list of specific skill themes was compiled. As there was extensive overlap in the skills identified by students at each question, the same theme list was applied to all questions. This approach also enabled subsequent comparison between questions. Where students' responses contained more than one skill within the same response 'dot point', they were coded to multiple themes. *e.g.* "ability to take initiative and work independently" was coded as "initiative" and "independent working/thinking"; "communication/people skills" was coded as "communication" and "interpersonal/social" skills.

A five per cent sample of survey responses from each question was checked for reliability by other members of the Monash Chemistry Education Research Group. They allocated each response to one or more of the themes and suggested new themes if they felt any were missing. The results of their analysis were compared with the primary researcher's and was found to achieve 86% agreement. This was further improved by modifying several theme titles and slightly adjusting the mode of

allocation to a few themes. A final inter-rater reliability of 91% was achieved following further coding by the primary researcher and two other researchers.

The remaining survey responses were coded using the finalised themes list and then a data table summarising each student's demographic data and their responses by skill theme was exported from NVivo using the Matrix coding function, for each of the three survey questions.

The theme list included sub-themes for types of laboratory, communication (generic communication, writing skills and presentation or public speaking skills) and thinking/problem-solving skills (problem solving, critical thinking, analytical and miscellaneous thinking skills). After exporting the data to Excel, these sub-themes were combined when completing the final data analysis and evaluation of results. This approach was taken to simplify the analysis due to the large number of skill themes identified.

The data were initially explored graphically and then the chi-square test (and where needed, the Fisher's exact test) were used to analyse whether the percentage of students identifying specific skills at each question differed significantly by university (Monash Clayton vs University of Warwick). Within each of the Monash Clayton and University of Warwick cohorts, the chi-square or Fisher's exact test was also applied to determine whether there were any significant differences in skill identification related to students' year levels or gender, by question. The chi-square and Fisher's exact tests were used as the data were categorical, since each student was either in the category of naming or not naming a skill. The level of significance used for differences in the percentage of students naming each skill theme was 0.010, as per the modified False Discovery Rate method (Narum, 2006) for 72 multiple comparisons (24 skills x 3 questions).

The mean, median, 25th percentile, 75th percentile and range for the total number of skills identified by students for each question were calculated. The Mann-Whitney *U* test was used to evaluate whether there was a significant difference between university campuses in the total number of skills students identified, or whether males and females named a different number of skills. The Kruskal-Wallis test was used to evaluate whether there was a significant difference between year levels in the number of skills identified, for a particular university campus.

2.8 The impact of identifying and reflecting on skill development experiences from the science curriculum

The impact of reflecting on curriculum-embedded skill development opportunities on Monash University science undergraduates was investigated using a mixed methods approach. This section will outline the intervention and the research approach used.

2.8.1 The intervention

Monash University science undergraduates were invited to participate in a voluntary semester long program between March and May 2017, to identify and reflect on employability skill development situations that they experienced during their degree units.

The program, called 'Skills to Work', began with a lunchtime workshop in Week 3 of the semester, in which students were briefly introduced to the concept of employability and employability/transferable skills and why these are important. Some literature data on the skills employers are looking for was shared, as well as some examples of common behavioural interview questions about transferable skills. Students were then briefly introduced to the idea of reflection; what it is, why it is important and some questions that can be used as prompts for reflection.

Students were shown the Monash University 'Student Futures' online platform, where they were encouraged to record their written reflections. Finally, they were challenged to record one curriculum-related skill development experience per week for the remainder of the semester. Five Week 3 workshops were run in total, with approximately 15-20 students at each session, with each student attending one workshop.

Following the workshop, students were sent an email each week for the remainder of the semester, to remind them to reflect. Such emails sometimes included a few ideas about skills students could consider and situations in which skill development may occur, to help students remain involved and engaged.

In the middle of the semester (week 7), participants were invited to attend a lunchtime discussion to share their experiences so far with the reflection program and ask any questions they might have. A total of seven mid-semester sessions were run such that no more than ten students attended each session, to allow each student to have an opportunity to contribute to the discussion.

In weeks 11-12 of the semester, participants were invited to attend a final lunchtime discussion to share their feedback on the program and receive a certificate of participation and a $25 gift voucher to thank them for their involvement in the research. Students were provided with refreshments at each workshop and discussion so that they didn't have to go without lunch in order to attend.

The program deliberately incorporated elements identified in the literature for successful use of portfolio-related reflection by education undergraduates (Driessen et al., 2005). These were: structure and guidelines (provided during the workshop and re-communicated in mid-semester discussions, weekly emails and the reflection platform), sufficient new and relevant experiences to reflect on (students were encouraged to draw on any experiences from the current year or prior years of their degree) and teacher or mentor availability for coaching (the lead researcher).

A summary of the program is shown in Figure 2.1.

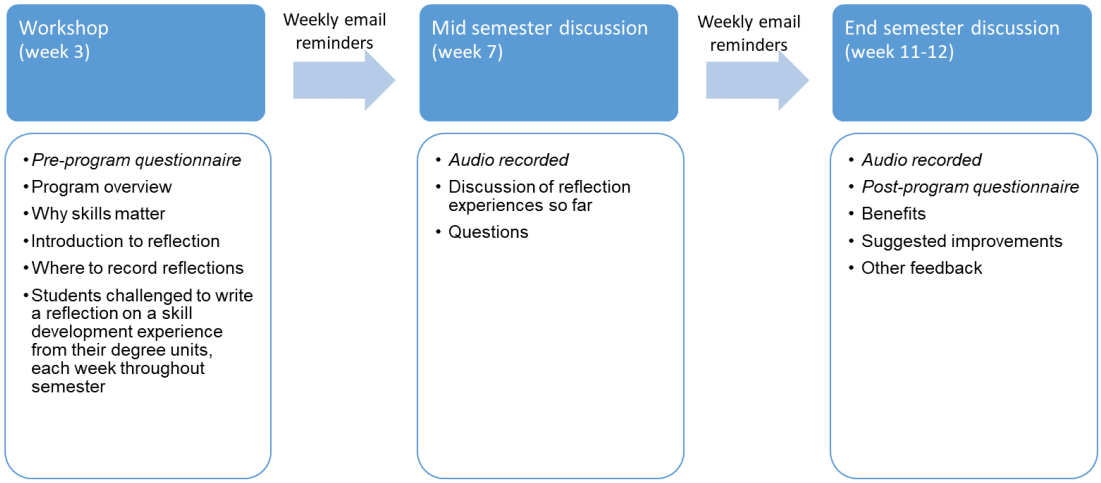

Figure 2.1 Skills reflection program

The 'Student Futures' online platform in which students recorded their skill reflections offers students a list of nine employability skills they can choose to reflect on; communication, creativity and innovation, intercultural competence, initiative and enterprise, planning and organisation, problem identification and solution, professionalism, teamwork and use of tools and technology (Figure 2.2).

Within 'Student Futures', students enter a name for their skill reflection, the year completed and a brief description of the activity. Next, they choose a skill from the list of nine provided and then are offered a series of examples of situations in which they may have developed each skill (*e.g.* for communication skills, "Describe a situation where you were able to use persuasion to successfully convince someone to see things in a particular way" or "Describe a time you were expected to read and synthesize complex information in a way that was easily understood by others" *etc*). A total of 65 pre-defined 'situations' are provided across the nine skills. Students choose the situation prompt that best fits their experience and then write their reflection using a 'STAR' (Situation, Task, Action, Result) structure, an approach recommended by many universities and professional recruiters (O'Leary, 2013). Additional prompt questions are available at each 'STAR' step by clicking on an information icon next to each step title (Figure 2.3). If students are uncertain which skill to choose, they can select 'I'm not sure' and will then be prompted with a range of situations. After selecting a situation, students will then be shown the skill to which this applies. 'Student Futures' also provides an overall summary of how many reflections the student has completed and on which skills (Figure 2.4). Participants can export their reflections at any time as a PDF document.

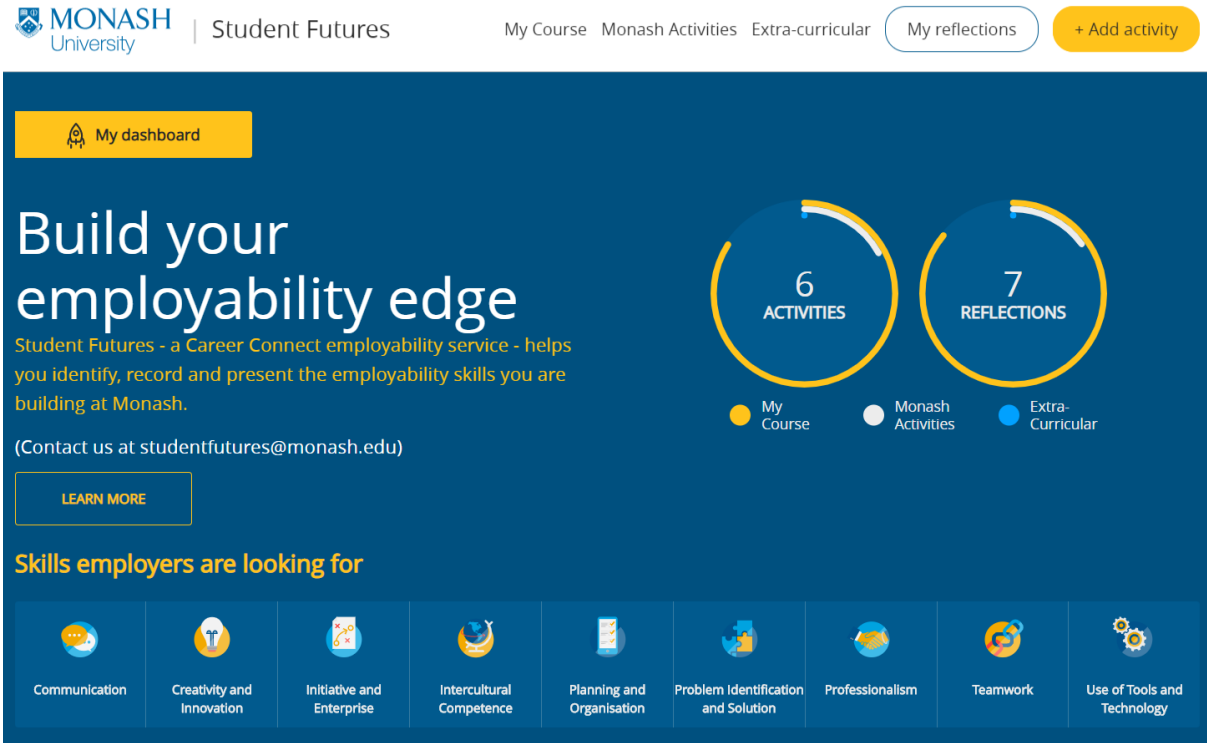

Figure 2.2. The 'Student Futures' platform opening screen 'dashboard', showing the nine skills available for reflection, a summary of how many reflections the student has completed and on what types of activities and menu options

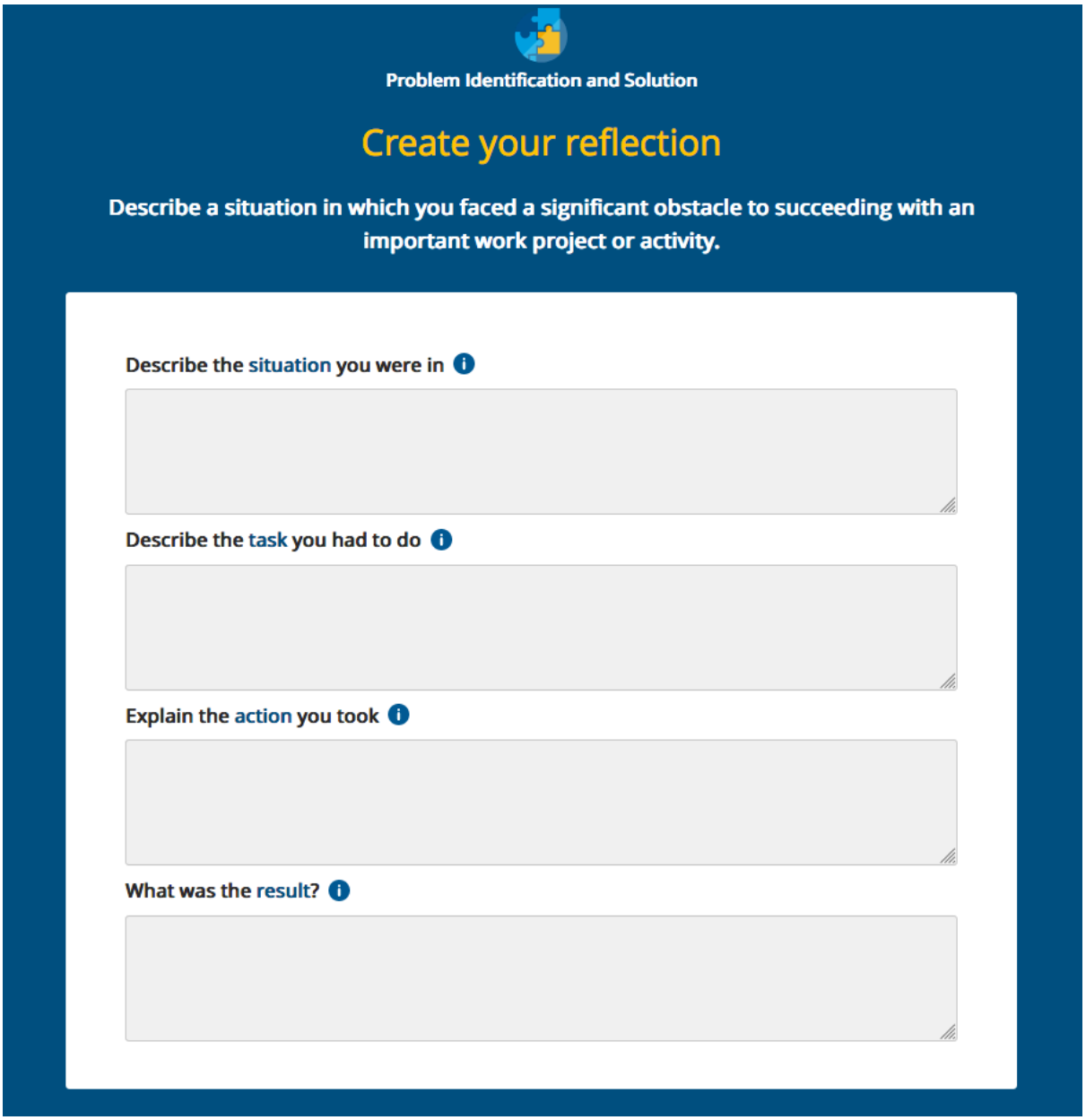

Figure 2.3. The 'Student Futures' reflection screen

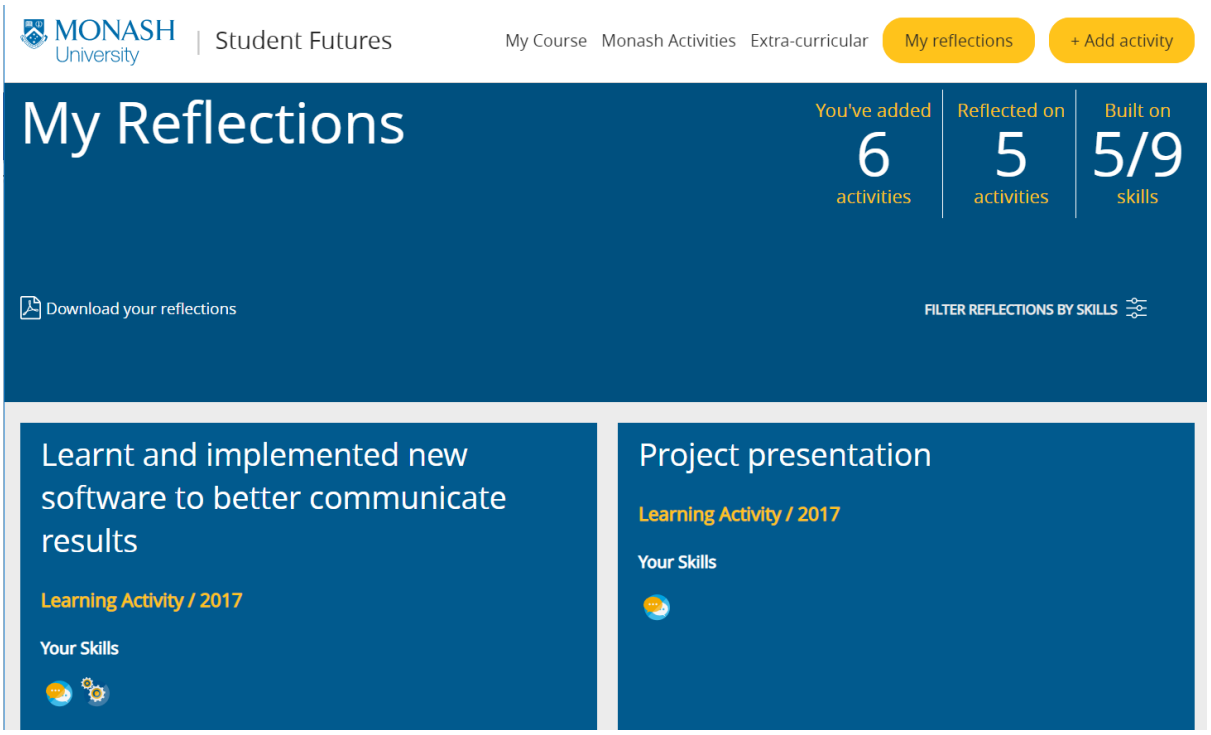

Figure 2.4. The 'Student Futures' platform 'My reflections' summary page, which shows how many skills have been reflected on, the titles of the reflections completed and the associated skills

2.8.2 Participants

Undergraduate science students (single or double degree) were invited to participate in the 'Skills to Work' reflection program using flyers placed in lecture theatres and in student study spaces and in person in second year core biology, chemistry, earth sciences and physics classes. Whilst all first to third year science undergraduates were welcome to participate, second year students were intentionally targeted since first year students (in their first semester) were likely to be focused on adjusting to university and have little spare 'headspace' or time (Denovan & Macaskill, 2017; Friedlander, Reid, Shupak, & Cribbie, 2007). Third year students were likely to be focused on decision making and applications for graduate employment and/or future education. Second year students potentially had available time for the program as well as further opportunities in their degree to act on any insights gained from their involvement.

Students indicated their interest in participating in the program by completing an online Google form, the link to which had been provided on the program flyers and on a PowerPoint slide shared in second year classes. The Google form asked each student to enter their name, email address, degree type, any dietary restrictions and which lunchtimes they were available in Week 3 of the semester. Respondents were emailed an invitation to attend a specific workshop based on the availability they provided in the form. 130 students completed the Google form, 91 attended an initial workshop and 60 students completed the program.

Only data relating to students who completed the program is presented and discussed. The demographics of these participants (Table 2.4) are typical of Monash University Clayton campus science undergraduates with the exception of 'year level'. Almost three quarters of participants were in the second year of their degree, in accordance with the recruitment strategy. Two

participants were in the first year of their degree, with the remainder predominantly being in their third year.

Table 2.4. Demographics of students who completed the 'Skills to Work' reflection program (n=60)

Demographic		% students	Degree	% students
Gender	Female	53%	Science	50%
	Male	45%	Science/Engineering	15%
	Other/rather not say	2%	Science/Arts	12%
Year level	1	3%	Science – Advanced (Research)	7%
	2	73%	Science/Biomedical Science	7%
	3	18%	Science/Computer science	3%
	4-6	5%	Science/Education	3%
Student type	Local/domestic	93%	Other	3%
	International	7%		
Science major				
	Biological sciences	38%		
	Chemistry	33%		
	Physics	12%		
	Atmospheric, earth or geosciences	12%		
	Biochemistry	7%		
	Maths	7%		

2.8.3 Research methodology

The research used a mixed methods approach with quantitative data collected using paper-based questionnaires administered pre-intervention (at the beginning of the initial workshop) and post-intervention (at the beginning of the end of semester discussion sessions). Qualitative data were collected through the mid and end of semester discussions and students' written reflections. Students were invited to share their completed reflections so that the skills reflected on could be identified and compared with survey and discussion data.

2.8.3.1 Survey instruments

Both pre- and post-intervention surveys (included in Appendices 3 and 4) incorporated demographic questions and six additional sections designed to probe the impact of participation in skills reflection. Participants were asked for their student ID number so that their pre- and post-intervention responses could be compared.

Details of the seven survey sections are:

- Demographic questions (gender, age, degree type (*e.g.* science, science/arts, science/engineering etc), degree year level, degree major, units enrolled in for the semester, language spoken at home)
- Self-rating of 22 skills identified from the literature as important in employment (Deloitte Access Economics, 2014; Sarkar et al., 2016; The Australian Industry Group, 2016; World Economic Forum, 2016). (Response scale: 1 Non-existent, 2 Very limited, 3 Limited, 4 Moderate, 5 Good, 6 Very good, 7 Excellent)
- Interest in further education opportunities (Honours, Masters, PhD, none)
- Career directions under consideration (seven options and 'Not sure')

- Best stage of university to start actively preparing for a job/career (seven options, by semester)
- Extent of agreement with eleven statements about course/degree satisfaction, course quality, motivation, skills and employment-related confidence (Response options: strongly disagree, disagree to some extent, neither agree or disagree, agree to some extent, strongly disagree)
- An open-ended question asking students if they had any other comments they'd like to make about their skills or career ideas or preparations

The scale used for the self-rating of student skills was adapted from the literature and piloted amongst two groups. Initially, six Monash Chemistry Education Research Group members were asked to self-rate their skills using three scales; a five point (worded) scale, a seven point (worded and numbered) scale and a ten point numbered scale anchored at each end (1 = very low skill level, 10 = very high skill level). When asked to provide their feedback on their preferred scale, the majority preferred the seven point worded and numbered scale.

The latter scale and a draft list of 21 skills was subsequently trialled amongst approximately 20 science undergraduates in the final year of their degree who had volunteered to participate in a career development workshop. These students self-rated their skills using the provided scale and then were asked for their feedback and any suggestions for improving either the scale or the skills list. The students indicated they found the scale quite satisfactory to use, but several students asked for 'written communication/report writing skills' to be better delineated so that it separated 'report writing' from other written communication skills such as writing emails, letters, applications etc. This change was implemented in the final skill self-rating question.

The post-intervention survey excluded demographic questions (as these had been collected in the pre-intervention survey and the two surveys were linked via student ID number) but included the following additional/adjusted elements to obtain students' direct feedback on their participation in the skills reflection program:

- Extent of attainment of eleven potential benefits of participating in skills reflection (Response options: none, a little, some, a lot).
- The open-ended comment question added a phrase asking students if they had any comments to make about their involvement in skills reflection (*i.e.* Is there anything else you'd like to add about your skills or your involvement in skills reflection, or any other aspect of job or career planning?)

The post-intervention survey also asked students for a direct rating of the degree of skill improvement they believed they gained during the semester as a result of their university course/units (response scale: none, a little, some, a lot). This involved the same 22 skills students were asked to self-rate in the earlier question (described above). The intention of this question was to compare whether those skills rated as most developed over the semester aligned with those for which students completed the most reflections. However, once the program began and it was clear that it would be beneficial to students to reflect on experiences from throughout their degree (not just the current semester), it was decided not to analyse the data from this question as the period of time involved in the question no longer aligned with the time period considered by the reflections.

2.8.3.2 Focus group and interview questions

Seven focus group discussions were recorded both at mid-semester and end of semester. 51 students attended a mid-semester discussion, 58 attended an end of semester discussion and two an end of semester interview. The latter two students were unable to attend a scheduled end of semester group discussion but participated in an interview as they wished to finish the program by completing the post-intervention survey and sharing their thoughts on the program.

The questions addressed in the mid-semester focus groups were:

- What has been going well regarding skills reflection?
- What has been challenging?
- What skills have you identified and in what types of situations?
- Are you noticing skills development situations as they happen or is it only afterwards when you think about it and try to identify some?
- How have you found the process of writing about the skills and reflecting on them?
- What do you think are the benefits (if any) of writing about skills experiences?
- Do you have any suggestions for others as to how to identify or write about skills experiences?

The questions addressed in the end of semester focus groups were:

- How have you gone with skills reflection over the second half of the semester? (What has gone well? What has been challenging? How have you approached it? Has it been harder or easier in the second half of semester?)
- What are the main skills you've identified over the semester?
- What are the situations in which you've noticed skill development?
- What do you think are the benefits, if any, from participating in skills recording and reflection?
- Are there any negatives or drawbacks from participating in skills reflection?
- Has the program impacted you in any way? Has anything changed for you as a result of participating?
- Do you have any suggestions for improvement of the 'Student Futures' reflection platform?
- Do you have any suggestions for improvement of the skills reflection program itself?
- Would anyone like to continue with the program next semester?

2.8.4 Data analysis

Survey responses were transcribed verbatim into Excel and explored graphically. Reponses to questions that were repeated on the pre- and post-intervention surveys (skill self-rating, further education interests, career aspirations, best stage of university to start career preparation and extent of agreement with eleven statements about course, motivation, skills and employment-related confidence) were paired by student number and analysed by the Wilcoxon signed rank test to test for statistically significant changes in student responses after the program. In total, 47

questions were analysed, so a 0.011 significance level was used to reduce the Type 1 error or chance of making a false conclusion, according to the False Discovery Method (Narum, 2006).

Focus group and interview recordings were transcribed verbatim, imported into NVivo 11 qualitative analysis software and analysed thematically as described in section 2.6.2. The inter-coder comparison showed good agreement (81%).

In terms of the written reflections, 35 students chose to share their reflections which numbered 235 in total. Each reflection specified which skill students had chosen to write about and these skills were manually summarised. The median number of reflections per student was calculated, as was the average number of reflections per student per particular skill and the percentage of all reflections that were about a particular skill. This data were compared with the change in students' self-ratings for each skill from the pre- and post-intervention surveys and the skills raised in qualitative discussions.

2.9 The impact of badging employability skill development opportunities in the undergraduate science curriculum

The impact of highlighting employability skill development opportunities in the undergraduate science curriculum by embedding skills badges on curriculum materials was evaluated using a mixed methods approach. This section will outline how the skills badges were developed, in which units/modules they were incorporated and how/where they were applied to curriculum materials. It will then describe the quantitative survey instrument and qualitative research approach used, the participants involved and how the data were collected and analysed.

2.9.1 The intervention

Recent literature was reviewed from a wide range of employers who hire science graduates, as well as from science graduates themselves, to identify the key transferable skills used by science and STEM graduates in the workplace (Deloitte Access Economics, 2014; Lowden et al., 2011; Sarkar et al., 2016; Saunders & Zuzel, 2010). In consultation with two science academics with extensive undergraduate teaching experience, a list of eleven skills or skill combinations were selected as relevant to science curriculum tasks and with the aid of a graphic designer, skills badges were designed for each (Figure 2.5).

Figure 2.5. Skills badges

Unit/module coordinators interested in participating in the skills badging study from the Monash University science faculty and the University of Warwick chemistry department were identified. Each coordinator chose the skills badges they felt applied to their curriculum and in which curriculum materials they should be embedded. These included workshop slides, student workshop manuals, student laboratory manuals/instructions, assignment instructions and/or associated relevant pages on the Learning Management System (LMS) / Virtual Learning Environment (VLE). Table 2.5 lists the units/modules involved in the study and the curriculum materials on which skills badges were applied within each. Table 2.6 shows which skills badges were embedded in each unit/module and how frequently.

The skills badges were displayed immediately underneath the learning outcomes for each task. For instructions that continued across several pages, badges were also embedded at important points during the task when the relevant skills were expected to be required. Some examples of the instructions for tasks in which skills badges were displayed are provided in Appendix 8. If a student manual was provided, a summary page showing all the skills badges was provided in the introductory section (included in Appendix 9). This page also included a paragraph explaining the purpose of the badges, why employability skills are important, how students could use the information gained about their skills and further references. The badges were displayed in colour in all units except GEN2041 (due to printing cost restrictions for the latter).

For the University of Warwick module CH2A5, the coordinator modified the intervention by awarding digital versions of two badges to students on successful completion of each of five assignments (*i.e.* ten badges in total), through the Virtual Learning Environment (Moodle). In this module, badges were displayed to only a very limited extent on curriculum materials. The other Warwick modules (CH155 and CH222) applied the main intervention of displaying badges.

Table 2.5. Summary of units/modules displaying skills badges and quantitative research conducted

University	Unit/module		Year level	Location of badges*	No. surveys completed (% cohort)	
					Pre-badging	Post-badging
Monash	CHM2911	Inorganic and organic chemistry	2	Laboratory manual	146 (48%)	139 (64%)
	GEN2041	Foundations of genetics	2	Laboratory manual & LMS/VLE	153 (85%)	165 (80%)
	SCI2010	Scientific practice and communication	2	Workshop workbook, slides & LMS/VLE	306 (52%)	282 (50%)
	CHM2962	Food chemistry	2	Laboratory manual	NA	166 (80%)
	BIO3070	Trends in ecology	3	Laboratory manual	NA	61 (67%)
	SCI3930	Career skills for scientists	3	LMS/VLE & workshop slides	NA	204** (83%)
Warwick	CH155	First year labs	1	Laboratory proformas & LMS/VLE	72 (45%)	107 (74%)
	CH222	Second year labs	2	Laboratory proformas & LMS/VLE	88 (49%)	128 (82%)
	CH2A5	Key skills	2	2 slides + 10 badges awarded through LMS/VLE	70 (39%)	66 (42%)

*On the LMS/VLE, relevant badges were shown under each laboratory/workshop title.
**Two cohorts (combined total).
NA = Not Applicable as pre-badging survey was not administered in these units

Table 2.6. Number of curriculum tasks^ on which each skills badge was displayed by unit/module

	Monash						Warwick		
Skills badges	CHM 2911	GEN 2041[a]	SCI 2010	CHM 2962	BIO 3070	SCI 3930	CH155	CH222	CH2A5[b]
Adaptability/ flexibility					1		2	2	1[b]
Commercial awareness	2		2	2		3		2	
Creativity		2	4		4	2	3		2[b]
Independence & initiative	2	10	3	4	4		3	6	
Numeracy	2	14		1	2	3	11	10	1
Oral communication			7	1	2	5			1
Organisation & time management	2	5	4	1		1	3	8	1
Teamwork	4	7	7	2	6	5	6	3	1
Thinking & Problem solving	3	17	9	1	5	1	11	6	1
Use of tools, technology & software	2	5	4	2	5	1	22	16	1
Written communication	4	4	8		1	2	2		1
Total number of curriculum tasks^ badged	9	18	11	6	10	10	27	20	5

^Curriculum tasks = laboratories, workshops and/or assignments

[a]For GEN2041, weekly laboratory tasks and 'problem sets' were both badged

[b]For CH2A5, all but two badges (1 x creativity and adaptability/flexibility) were awarded through VLE prior to survey

2.9.2 Survey instruments and survey data collection

A paper-based questionnaire (included in Appendix 5) was developed asking students to what extent each unit/module provided an opportunity to develop 19 specific skills ('none', 'a little', 'some' or 'a lot'). These 19 skills included the badged skills, however they were divided into their component parts where relevant *e.g.* 'Thinking and problem solving' was divided into 'analytical/critical thinking' and 'problem solving' skills on the survey and 'Independence and initiative' was divided into 'independent learning skills' and 'initiative' on the survey. The badges had grouped some related skills together to limit the number of badges and not overwhelm students by displaying too many on each task. These grouped skills were separated in the survey to evaluate whether students had recognised the individual skills (and to what extent), rather than simply recalling the 'badge label'. Several other skills not highlighted strongly in the employability literature (literature research, experiment design, ethical awareness) were also added to the skills list. This was to ensure the survey was not biased by listing only skills related to the badges and to provide students an opportunity to respond on most skills they were likely to develop.

Students were also asked how important they thought each skill was likely to be in helping them obtain a job and succeed at it after graduation ('not important', 'slightly important', 'fairly important', 'very important', 'extremely important').

The survey also covered career aspirations (seven categories plus 'other', with opportunity to specify, and 'not sure') and demographic data (gender, age, year level, domestic/international, degree type *e.g.* science, science/engineering, science/arts etc. and degree major).

Students were provided an opportunity to add their own thoughts and comments in two open-ended questions: one followed the question asking students to what extent each unit/module provided an opportunity to develop the 19 specific skills ('Is there anything else you'd like to add about the skill development opportunities offered by Unit XXX, or Unit XXX in general?'). The second followed the question asking the importance of each skill for students' future job/career ('Are there any other skills you think will be important in helping you obtain a job, or anything else you'd like to add about skills and job preparation in general?').

This survey was administered to students at the end of the teaching period of six units/modules before badges were added to curriculum materials (pre-badging survey, administered March-May 2017), and then repeated a year later with a new cohort of students after the badges had been added and had time to take effect (post-badging survey, administered March-May 2018).

The post-badging survey (included in Appendix 6) included additional questions: how often students noticed the badges on the unit/module course materials ('never', 'occasionally', 'sometimes', 'fairly often', 'frequently'); students' extent of agreement with seven statements about the impact of the badges ('strongly disagree', 'disagree to some extent', 'neither agree or disagree', 'agree to some extent', 'strongly agree'), and a further open-ended question offering an explicit opportunity to provide feedback on the badges ('Do you have any other comments about the skills badges?').

For an additional three units (CHM2962, BIO3070, SCI3930), only the post-badging survey was administered, due to timing constraints (administered October 2017 for CHM2962 and BIO3070 and May and October 2018 for SCI3930).

Several small changes were made to the survey methodology during the initial stages of the project: Firstly, after administering the pre-badging survey in three modules at the University of Warwick, it was noted that students already showed quite strong recognition of some skills and that perhaps the question itself may have been a prompt to students. As a result, it was decided to add an additional question asking students to what extent they had recognised they had the opportunity to develop these skills **at the time they were doing the unit/module** ('not aware', 'slightly aware', 'fairly aware', 'very aware'). This question was included in the pre-badging surveys administered at Monash and in all post-badging surveys. (However, upon analysis, it was not found to provide any significant additional value and so was not highlighted when communicating and discussing results).

Secondly, when the badges were initially developed, 'creativity' was not included, as the project team thought this skill was unlikely to be required to any significant extent in the units/modules for which the research was to be conducted. However, creativity was later identified by several unit/module coordinators as important in some student assignments. As a result, a creativity badge was generated and applied to curriculum materials in a number of units/modules and this skill was added to the post-badging surveys (although it was not included in the pre-badging surveys).

Students were invited to complete the surveys during, or at the end of, a laboratory class, workshop or lecture. University of Warwick and Monash CHM2911 students were offered refreshments. Table 2.5 summarises the number of participants who completed surveys on each unit/module and the corresponding percentage of each cohort.

2.9.3 Focus group and interview participants and questions

Students from all units/modules except SCI3930 were invited to participate in focus groups, with refreshments provided. Eighteen student focus groups (involving 98 students) and five interviews (with students who couldn't attend the scheduled focus groups) were conducted (ten pre- and 13 post-badging). The questions discussed were:

- What skills did the unit/module offer you the opportunity to develop?
- Which aspects of the unit/module offered the opportunity to build these skills?
- How easy was it to recognise these skills could be developed through the module? Did you recognise or notice it at the time you were doing the unit/module?
- What impact, if any, does it have on you when you recognise you're building skills in your course?
- What skills do you think will be important for you to gain a job after you graduate and succeed at work?

Post-badging only:

- (If not mentioned) Did you notice skills badges on some of the unit/module materials?
- What do you think their purpose was?
- Were they helpful in any way?
- Were there any drawbacks to displaying the badges?
- Did teaching staff talk about the skills/badges at all?
- Do you think there are any improvements that could be made to the badges or the way they were implemented?

For all units/modules except SCI3930 and CH2A5, TAs were invited to participate in focus groups or interviews at the conclusion of the teaching period when badges were displayed. Seventeen TAs (13 from Monash University and four from University of Warwick) chose to participate in the research. They were asked the following questions in focus groups/interviews:

- What skills do you think students had the opportunity to develop in the unit/module?
- Did you notice the skills badges on some curriculum materials, and if so, what did you think their purpose was?
- Do you think the badges had any impact on or were helpful in any way to students and if so, in what ways?
- Do you think the badges were a fair representation of the transferable skill development opportunities offered by the unit?
- Were the badges introduced by or talked about at all by teaching staff?
- Did the badges have any impact on teaching staff/you in any way? If so, in what ways?
- Do you think there are any drawbacks to displaying the skills badges?
- Are there any improvements you could suggest to the badges or the way they were implemented?

2.9.4 Data analysis

Survey data were transcribed into Excel and explored graphically. For each unit/module, the Mann-Whitney *U* test (SPSS software) was used to compare pre- and post-badging survey responses to three questions that occurred on both surveys, to identify any statistically significant differences that occurred after the badging intervention. Where collected in both pre- and post-badging surveys (*i.e.* for units SCI2010, CHM2911 and GEN2041), the Mann-Whitney *U* test was also used to compare responses to the question asking students' extent of awareness of skill development at the time they were doing the unit.

Fisher's Exact test (SPSS) was used to explore the relationship between how frequently students noticed the badges and their extent of agreement with seven statements about the badges.

As 42 comparisons were made between pre- and post-badging survey responses for each unit/module, the standard 0.05 significance level was reduced to 0.0116 (0.012 in practice) to decrease the likelihood of a Type 1 error ('false positive'), as per the False Discovery Rate Method (Benjamini & Yekutieli, 2001; Narum, 2006).

Twenty-three student (n = 103) and eight TA (n = 17) focus group and interview recordings were transcribed verbatim, imported into NVivo 11 qualitative analysis software and analysed using thematic analysis as described in section 2.6.2. The inter-coder comparison achieved 76% agreement.

Responses from the survey open-ended question were also imported into NVivo 12 and independently analysed for themes and coded. Coding of responses from two units/modules by two other researchers achieved 86% agreement.

2.10 The impact of incorporating skills reflection into the undergraduate chemistry laboratory curriculum in combination with displaying skills badges

The impact of involving students in writing a short reflection on a skill they identified as developed or used during a chemistry laboratory task in which skills badges were also embedded within the instructions, was evaluated using a mixed methods approach.

2.10.1 The intervention

A short reflective question was added to the end of the post-laboratory assessment task/pro forma for five or six experiments in each of two chemistry units at Monash University in second semester 2018 and second semester 2019 (CHM2962) and first semester 2019 (CHM2911). The question was worded as follows:

> REFLECTION ON AN EMPLOYABILITY SKILL
>
> Identify an employability skill* you felt you used or learned about in this laboratory exercise and write a one paragraph personal reflection on how you demonstrated, developed or learned about this skill in any aspect of the experiment. You can also reflect on any ways in which you feel you could improve in this skill in the future.
>
> *Notes: Page X of the lab manual shows some employability skills you could reflect on.
>
> For guidelines and tips on reflecting, with examples, see "Student guide to reflecting on employability skills" on the Moodle page for this laboratory exercise.

This question was allocated one mark out of a total of 20 marks for the assessment.

A two page document entitled 'Student guide to reflecting on employability skills' (included in Appendix 10) was prepared as a resource for students who wanted or needed some guidance on how to reflect. The first page provided information on what reflection is and the benefits of reflection, guidelines on how to reflect, some prompt questions to help reflection, some useful reflective words and references to some further resources. The second page gave three examples of skills reflection paragraphs (one annotated as 'poor' and two as 'good') with written feedback. A link to this document was provided on the LMS (Moodle) page for every experiment for which a skills reflection was required.

A two page document "A guide to marking reflective writing on employability/transferable skills" (provided in Appendix 11) was included in the TA handbook for the relevant units. This included a brief introduction to reflection, guidelines on how to reflect, some prompt questions for reflection (as shared in the 'Student guide to reflecting on employability skills') and a sample list of skills and qualities that students could reflect on. It also included a few guide points such as that students weren't required to reflect on all seven prompt questions (these were a guide only to prompt reflection) and that students could reflect on any aspect of the experiment including preparation, implementation, analysis and write up. On the second page, a marking scheme was provided, as well as four examples of sample skills reflections with suggested marks (0, 0.5, 1, 1) and comments. This marking scheme was also provided underneath the skills reflection question in each of the relevant experiments in the TA handbook, along with a reference to the more detailed pages provided earlier in the handbook.

TAs for these two units were also provided with semi-automated Excel-based rubrics for marking all post-laboratory assessments. An additional line was added to these rubrics for the skills reflection assessment, as shown in Table 2.7:

Table 2.7. Rubric provided to TAs for marking skills reflection questions

	0 marks	0.5 mark	1 mark
Employability skill reflection	Does not identify an employability skill. Writes only about what happened in the experiment - chemistry & chemical techniques	Identifies a specific employability (transferable) skill used during the lab exercise but little personal reflection on this skill. Still a significant focus on the outcomes of the experiment or other topics.	Personal reflection focusing on one (or more) transferable/employability skill(s) and how the student demonstrated, developed or learned about that skill and/or how they plan to improve this skill in the future

This was a re-formatted version of the marking scheme provided to TAs in the TA handbook.

For unit CHM2962, the lead researcher provided a short session within a TA training day that was held just prior to the commencement of the initial semester in which students were asked to complete skills reflections (Semester 2, 2018). In these sessions, TAs were given a brief introduction to reflection and the purpose of asking students to write skills reflections was shared. The document 'A guide to marking reflective writing on employability/transferable skills' was handed out and discussed, with particular attention to reviewing the sample skills reflections and marks. An opportunity was provided for TAs to ask questions. Five out of nine TAs attended this training session. For unit CHM2911, no TA training session on marking skills reflections was provided.

2.10.2 Survey instruments, survey data collection and participants

The paper-based survey instrument used for this study (included in Appendix 7) was adapted from that used for evaluating the impact of badging employability skill development opportunities in the science curriculum. The questions repeated in the skills reflection survey instrument were as follows:

- Demographic-related questions (gender, age, degree type, degree year level, student type and degree major)
- To what extent each unit/module provided an opportunity to develop 19 specific skills ('none', 'a little', 'some' or 'a lot')
- Open-ended question asking students if there was anything they'd like to add about the skill development opportunities offered by the unit
- Frequency with which students noticed skills badges on course materials
- Extent of agreement with seven statements about the skills badges

These questions were repeated so that the impact of the skills reflection intervention on skill recognition, frequency of noticing the badges and perceptions of the badges could be evaluated by comparing responses to the relevant questions before and after the intervention.

Two additional sections were added to the survey instrument for this study to determine the reaction of students to writing the reflections, any perceived benefits and their understanding of the task and support received. Firstly, a series of nine statements on students' experience of writing the skills reflections were presented, including whether students liked writing them, how easy it was to identify a skill or write the reflection, whether they understood the purpose of the tasks or knew where to find help and their attitude towards preparation for employment. Students were asked to indicate their extent of agreement with each of these statements (strongly disagree, disagree to some extent, neither agree or disagree, agree to some extent, strongly agree). Questions about students' attitudes towards employment preparation were asked to ascertain whether there was a relationship between these and engagement with reflection on employability skills, or the badges.

Secondly, seven statements were provided about the potential benefits of writing skills reflections and students were asked to indicate to what extent (if any), writing skills reflections helped them in each of these ways (not at all, a little, to some extent, a lot).

The last question in the survey was open-ended and gave students an opportunity to add any further comments about writing skills reflections, skills badges or any other aspect of the unit.

CHM2962 students were offered the opportunity to complete the survey in a workshop close to the end of semester (weeks 10 to 12). CHM2911 students were offered the opportunity to complete the survey straight after completing their second to last practical session for the semester, with refreshments provided. For both cohorts, the contexts in which the surveys were administered were the same as for the prior year when the post-badging survey data were collected, with the exception that CHM2911 students were surveyed one week earlier for this aspect of the study.

In total, 305 CHM2962 students and 166 CHM2911 students filled out the survey, representing 66% of the CHM2962 and 62% of the CHM2911 cohorts. Details of the student participants are presented in Table 2.8. The gender, student and degree type demographics are typical of Monash University chemistry subject cohorts. It is noted however that whilst CHM2911 students were primarily in the

second year of their degree and over 70% were taking a chemistry major, half of CHM2962 students were in the third or later year of their degree and less than half were taking chemistry as a major.

Table 2.8. Demographics of participants in skills reflection and badging quantitative research

Unit:	CHM2962^		CHM2911^^	
Demographic	Number of responses	% sample	Number of responses	% sample
Total	305		166	
Gender:				
Female	163	53%	88	53%
Male	139	46%	77	46%
Other/rather not say	3	1%	1	0.6%
Student type:				
Local/domestic	237	78%	133	80%
International	66	22%	33	20%
Degree:				
Science	177	58%	88	53%
Biomedical Science	21	7%	9	5%
Science double degree	98	32%	67	41%
Other (Engineering, IT, Education)	6	2%	1	0.6%
Degree year level:				
One	4	1%	9	5%
Two	175	57%	132	80%
Three	87	29%	23	14%
Four or five	37	12%	2	1%
Science Degree major:				
Chemistry	146	48%	118	71%

^CHM2962 students were from two cohorts (Semester 2, 2018 and Semester 2, 2019), with 144 from 2018 (47%) and 161 from 2019 (53%)

^^CHM2911 students were from one cohort (Semester 1, 2019)

2.10.3 Focus group questions and participants

Students from both units were invited to participate in focus groups, with refreshments provided. Six student focus groups were conducted, three for each unit, with refreshments provided. A total of 29 students participated. The questions discussed were:

- What skills do you think you had the opportunity to develop in Unit XXX this semester?
- What do you think was the purpose of asking you to reflect on an employability skill in some of the lab reports?
- Did anyone explain the purpose of the reflections to you?
- Did you find writing the skills reflections easy or difficult? Why? Did it get easier with time?
- What benefits, if any, did you feel you gained from writing the skills reflections?
- Did you feel you had guidance and support available to you for writing the reflections if you needed it?
- Do you have any suggestions to make about how to improve how the reflections questions were asked or implemented?
- Did you notice skills badges in the lab manual? Were they beneficial in any way?

Three focus groups were also conducted involving TAs (one for CHM2962 and two for CHM2911, in order to accommodate the availability of the TAs), with refreshments provided. Eight TAs participated in total. The questions discussed were:

- What skills do you think students had the opportunity to develop in Unit XXX this semester?
- What do you think was the purpose of asking students to reflect on an employability skill in some of the lab reports?
- Did you talk to students at all about the skills reflections; how to write them or their purpose?
- How did students go with writing their reflections? Were they of reasonable quality?
- Do you think the students gained any benefits from writing the skills reflections?
- Did the reflections students wrote have any impact on you? In what way?
- Were you comfortable marking the reflections? Did you receive sufficient guidance?
- Did you notice skills badges in the lab manual? Do you think they were beneficial in any way?
- Can you suggest any way to improve how the skills reflections were implemented?

In all instances, the first question asked was which skills students had the opportunity to develop in the unit. This was used as an initial 'warm-up' question, to engage participants in the topic in a comfortable and relevant way and turn their thinking towards their experiences in the unit.

2.10.4 Data analysis

Survey data were transcribed into Excel and explored graphically. The Mann-Whitney *U* test (SPSS software) was used to compare pre- and post-reflection intervention survey responses to questions that occurred on both surveys, to identify any statistically significant differences that occurred after the intervention. For both CHM2962 and CHM2911, this involved comparing responses obtained at the end of the semester in which students completed skills reflections in the presence of skills badges with those obtained at the end of the semester in which skills badges alone were applied to see if the reflections resulted in a different impact than displaying skills badges alone.

For CHM2911, an earlier data set was also available, collected at the end of the semester prior to adding skills badges to curriculum materials (*i.e.* the pre-badging survey). Comparisons were made between this data set and the most recent data set (collected from students who had completed skills reflections and been exposed to curriculum materials with skills badges applied) as to the extent to which students believed each unit/module offered the opportunity to develop 19 specific skills. This comparison was made to investigate whether the combination of skills badges and skills reflections would result in a different extent of uplift in recognition of skills (if any) than applying skills badges in isolation.

It was hypothesised that student attitudes towards employment preparation during their degree and their understanding of the importance of being able to express their employability skills may have impacted their responses to the skills badges and skills reflection tasks. The Spearman rank order correlation test was used to test this hypothesis by evaluating whether there was a relationship between student responses to statements about the ease and benefits of writing reflections or the benefits of skills badges and their responses to the following three statements:

- 'It is important to start preparing now for a job/career'

- ‘All the matters right now is completing my degree units and doing well in assessments. I’ll worry about a job/career later’
- ‘I understand why it’s important to be able to talk or write about my employability skills’

In total, 27 comparisons were made between pre- and post-reflection survey responses for CHM2962 and 51 comparisons were made to evaluate the above relationships between questions within the survey. Hence, the standard 0.05 significance level was reduced to 0.00987 (*i.e.* less than 0.01) to decrease the likelihood of a Type 1 error (‘false positive’), as per the False Discovery Rate Method (Benjamini & Yekutieli, 2001; Narum, 2006). For CHM2911, 18 additional comparisons were made with pre-badging survey responses, so a 0.00921 significance level was applied (*i.e.* less than 0.01 in practice).

Six student (n = 29) and three TA (n = 8) focus group and interview recordings were transcribed verbatim. These were imported into NVivo 12 qualitative analysis software and analysed using thematic analysis as described in Section 2.6.2, with a separate analysis completed for each data set (students and TAs). Coding of responses from two transcripts (one from each unit) by two other researchers achieved 74% agreement.

2.11 Limitations

A limitation of this study was that it primarily involved a cross-sectional design methodology (Busk, 2014) wherein students from a particular year level (in the skills survey) or a particular unit before or after an intervention (the skills badges or in-curriculum reflection) were sampled at only one point in time rather than multiple times. Thus any differences between year levels or between units could be due to differences between cohorts involved rather than the interventions. However, for the skills badging intervention any cohort effects are likely to be mitigated as the study was carried out across nine different units, at two universities, and across several years and disciplines.

For the skills survey, students were asked to identify “up to five skills” at each of the three questions. This upper limit of five may have prevented some students from identifying additional skills. However, since 71-90% of students named four skills or fewer at each of the three questions, and some students did name more than five skills, this did not appear to be a limitation for most students.

The semester-long skills reflection program involved only volunteers who were likely to be interested in the topic and motivated to participate. Students in the volunteer program experienced a high degree of interaction with a tutor, which may have enhanced their understanding, engagement or motivation. This degree of tutor interaction may not be possible if implemented in the curriculum and thus a regular cohort of students may not be as engaged or interested as those who volunteered. For these reasons, an in-curriculum skills reflection intervention was also implemented.

The skills badging and skills reflections elements of the study primarily focused on second year units and students. This was not a deliberate strategy but occurred because these units were being delivered within the timeframe of the study and contained tasks suitable for displaying badges or skills reflection. It may be that first and third year units may not show the same impact from displaying skills badges or in-curriculum reflections as those evaluated.

The skills reflection research was undertaken at a single Australian university and the in-curriculum reflection research was undertaken only within the laboratory component of two chemistry units. It

cannot be assumed that the results from these research elements are generalisable to other Australian universities, international institutions, other science disciplines or a non-laboratory context, without further research in such contexts. Whilst the skills survey and skills badges were piloted at two universities, these institutions both recruit students with strong academic and higher socio-economic backgrounds. Hence the results of this study may not be generalisable to institutions with students from more diverse academic and socio-economic backgrounds.

It is important to consider whether the data collected were representative of each of the respective student cohorts. For the skills survey, the response rate was 50% to 64% for the Monash cohorts and 39% to 74% for the Warwick cohorts. For the skills badging study, the response rate pre-badging varied from 39% to 85% across the six units, and post-badging, the response rate was 42% to 82%. Whilst it would be desirable to improve the lower end of these achieved response rates (39% and 42%), in most cases a majority of students responded to the surveys, providing good representation of the relevant cohorts. However, it is not possible to be certain that the results are entirely representative of each cohort. It is possible that a significant number of poorly motivated or low achieving students may not have responded to some of the surveys, and that such students may have different, potentially poorer, levels of skill recognition. Such students may also respond differently to the skills interventions, either benefiting more or less than the current research indicates.

Whilst all students from the respective units were invited to participate in focus group discussions, participants were volunteers and may not have been representative of their cohorts. It is likely that the students who volunteer for focus group discussions may be more motivated and engaged then the larger cohort or have a particular viewpoint they wish to share. However, this issue should be alleviated by the process of triangulation used to compare the quantitative survey data with the qualitative data from focus group discussions. In the skills badging questionnaires, many open text comments expressing a range of both negative and positive viewpoints were submitted by students, which were also able to be triangulated with the focus group data, ensuring a wider representation of the cohort in the qualitative data. Whilst the in-curriculum skills reflection questionnaire also provided an open text opportunity for students, very few students completed this and so the responses were not used in the analysis process.

Finally, the lists of skills provided in the skills badges and skills reflection questionnaires are acknowledged to be a form of prompting. It is likely that if students were asked to name skills without such a list being provided, their responses may not have been as extensive. In addition, both positive and negative potential impacts were invited on the post-badging and post-reflection questionnaires and the questions are likely also to have acted as prompts. To help alleviate the 'prompting' limitations of the survey questions, the qualitative data obtained from the open questions asked in the focus groups and interviews provided an understanding of students' unprompted thoughts on the skills developed and the benefits and deficits of each intervention.

3 Undergraduate recognition of curriculum-related skill development and the skills employers are seeking

The first research question considered was whether science undergraduates at Monash University and the University of Warwick recognise that they are developing transferable skills during their degree and whether they value such skills. This question was addressed by developing and administering a survey which asked 990 science undergraduates from these two universities three open-ended questions regarding what skills they think they have developed during their degree, what skills they would like to further develop during their degree and the skills employers are looking for, from graduates. Participants were also asked several demographic and degree-related questions.

The results of the survey were analysed and published as a peer-reviewed paper in the journal *Chemistry Education Research and Practice*. As well as presenting and evaluating the extent to which students recognised and valued curriculum-embedded skill development opportunities, the paper also considered whether students' year level in the degree or gender significantly impacted the skills that students identified. It also compared the students' views of employer-valued skills to the views of employers and graduates as reported in the literature. The paper is presented in the following pages.

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Undergraduate recognition of curriculum-related skill development and the skills employers are seeking

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Employers of chemistry graduates are seeking a range of transferable skills from prospective employees, and academics are increasingly seeking to build employability skill development opportunities into the undergraduate curriculum. However, research suggests that undergraduates do not recognise or value such skill development without prompting. This recognition is essential if graduates are to be able to articulate their skills in the employment process. This study involves research amongst almost 1000 undergraduates studying chemistry at two institutions, using open-ended questions to collect qualitative data. The extent to which students recognised course-related skills development and understood the skills that employers are looking for was investigated, as was their desire to develop additional skills. Similarities and differences in student views between institutions are discussed, as well as trends across year levels and by gender. Results indicate that undergraduates studying chemistry are most likely to value and recognise development of some key skills sought by employers (teamwork, communication, thinking/problem solving, organisation/time management and laboratory/practical skills), but are very unlikely to value or recognise others (numeracy, independent learning, commercial awareness, interpersonal, research, computer/IT, creativity/innovation, flexibility/adaptability and initiative). Opportunities to develop the latter skills and recognition of the value of doing so will require improved communication with students and/or provision of new experiences within the curriculum.

Introduction

It is well established that employers are seeking a range of transferable skills from chemistry and other STEM graduates, in addition to discipline specific knowledge and skills (Purcell *et al.*, 2008; Saunders and Zuzel, 2010; Lowden *et al.*, 2011; Deloitte Access Economics, 2014; Sarkar *et al.*, 2016; Yasin and Yueying, 2017). These skills are also referred to as generic, key or employability skills and can include communication and interpersonal skills, teamwork, leadership, critical thinking, problem solving, organisation and time management, independent learning, initiative, flexibility/adaptability, creativity and innovation, commercial or business awareness, numeracy and IT skills.

Such skills are widely relevant, being valuable in an academic or research career (Taber, 2016) and likewise sought by employers in a wide variety of sectors outside of STEM (DEST; ACCI; BCA, 2002; Mohamed, 2008; Eisner, 2010; Wendler *et al.*, 2012; The Australian Industry Group, 2016).

Whilst the need for these skills is clear, employers have reported that some chemistry and science graduates lack the depth or breadth of the skills they require (Purcell *et al.*, 2008; Lowden *et al.*, 2011; Wendler *et al.*, 2012). Chemistry and science graduates themselves have also reported a deficit in some key skill areas (Hanson and Overton, 2010; Sarkar *et al.*, 2016).

Universities have responded to this situation by increasingly seeking to build opportunities for students to develop such skills into the curriculum (Runquist and Kerr, 2005; Yorke and Knight, 2006; Baker and Henson, 2010; Ashraf *et al.*, 2011; Bennett *et al.*, 2015). However, it is not clear whether students recognise the development of these skills or understand their importance. Without such recognition of skill development, it could be argued that academics' efforts to incorporate them into their courses are, at least to some extent, wasted. Recognition of skill development is essential for students to be able to articulate them, with examples, in the job application and interview process (Jackson, 2013). Recognition and valuing of specific skill competences is also likely to impact on graduates' ability to transfer these skills to new (workplace) contexts, thereby impacting their capability to contribute and succeed at work (Jackson, 2013).

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Recognition of their wider skill set also enables graduates to apply for and obtain a broader range of jobs (Mellors-Bourne *et al.*, 2011). Some government and academic commentators reflect the expectation that graduates majoring in a STEM discipline will be employed in a "STEM job" (Mellors-Bourne *et al.*, 2011). Others consider that STEM graduate employment in roles and professions outside their discipline is highly desirable, with Rodrigues *et al.* (2007) stating "a case can be made for attempting to increase the size of this group to ensure that scientifically literate people are at the decision-making levels of industry and government". Research also indicates that businesses employing STEM-skilled staff are significantly more productive and innovative than those who don't (Office of the Chief Scientist, 2016), and that employers value the skills STEM-trained staff bring to the workplace, even when their STEM qualification isn't necessary for the job they're fulfilling (Deloitte Access Economics, 2014).

Not only can employment of chemistry and science graduates outside the STEM sector have the potential to benefit the economy and society, it may be increasingly essential for many of these graduates, due to the highly competitive nature of some discipline-based job markets, with supply currently exceeding demand in chemistry and other scientific fields (Xue and Larson, 2015; Norton, 2016). However, in order to secure employment outside their discipline major, chemistry and science graduates are reliant on being able to recognise and articulate their transferable skills. Indeed, a significant proportion of science graduates are already employed in such jobs (Rodrigues *et al.*, 2007; Mellors-Bourne *et al.*, 2011; Norton, 2016), primarily using these generic skills rather than the content knowledge developed during their degree.

Not only must they recognise skill development, it is also vital that undergraduates realise the value of transferable skills, as they will then be more motivated to maximise the opportunities provided at university to develop them, since recognition of value, motivation and learning are strongly linked (Pintrich, 2003; Tymon, 2013).

A number of studies have shown undergraduate science students do value the development of a range of transferable skills. When asked explicitly and quantitatively about named transferable skills, environmental/biological, biomedical and general science degree students rated them as important and/or developed, but to varying extents, depending on the specific skill (Leggett *et al.*, 2004; Matthews and Hodgson, 2012; Varsavsky *et al.*, 2014; Matthews and Mercer-Mapstone, 2016).

Recent studies have also investigated the views of chemistry undergraduates on the perceived value and/or development of listed skills. In a UK study by Galloway (2017), teamwork, problem solving, organisational/time management, independent learning ability, practical skills and interpretation of experiment data attracted the highest number of useful/very useful ratings from a list of ten chemistry-related skills and ten generic skills. This study also found that a student's intended career path impacted the perceived usefulness of specific skills, especially discipline-related ones.

In a Singaporean study (Yasin and Yueying, 2017), students were asked to tick five skills or attributes they thought to be important in securing a job, and that they had acquired during their chemistry degree, from a list of fourteen. The top five attributes selected as most important for gaining a job were work experience, communication, practical, teamwork skills and theoretical knowledge; whilst practical skills, theoretical knowledge, analytical and quantitative, independent learning and problem solving skills were those most commonly chosen as developed through their coursework. Whilst the results of this Singaporean study may not be directly comparable to the current Australian/UK study due to potential course and cultural differences, it is illustrative that this issue is also of interest in other regions.

Each of these studies has been undertaken by asking students to respond to skills in a list provided to them, most often on a rating scale for each skill. Responding to such a skills inventory in a survey prompts students to think about each skill and to consider that each may be important or developed to some level during their degree. However, additional research suggests that students may not recognise employability skills developed within a degree without such prompting (Whittle and Eaton, 2001; Tomlinson, 2008).

Tomlinson's qualitative multi-faculty study asked final year undergraduates what is required to get a good job (Tomlinson, 2008). This study concluded that students feel employers are looking for personal skills and attributes in addition to a 'good quality' degree, although the students cited extra-curricular activities as the vehicle for development of these, and recognition of transferable skill development within the degree was not mentioned.

Likewise, Whittle and Eaton (2001), quoting a study on biochemistry undergraduates, observed "It has been shown in science graduates that when skills are taught through an integrated, student-centred system, students may remain unaware of the opportunities offered by their course to improve their skills". That is, when development of a skill is curriculum-embedded, students may not recognise its improvement without being directed to look for it.

In light of the above research, it cannot be assumed that the employability skills that academic staff consider have been built into a chemistry or science curriculum are recognised by students and hence able to be drawn upon when seeking employment (or further study) and transferred to their future workplace(s).

The purpose of this study was to understand which skills undergraduates studying chemistry recognise that they are developing during their degree and which skills they value, without any prompting from a list identified by their academic teachers or other research. The underlying research questions the authors sought to address through this study were:

- Which transferable skills do science undergraduates studying chemistry:
  - recognise they are developing during their degree?
  - wish to further develop during their degree?
  - believe employers are looking for, from graduates?
- Do the skills identified vary significantly by university (Australian *vs.* UK), year level or gender?

It is intended that the outcomes will inform whether action needs to be taken to better highlight specific skill development opportunities and their importance to chemistry undergraduates and/or provide more or improved skill related tasks within the curriculum.

As a further comment, whilst the employability driver behind equipping undergraduates with transferable skills and their recognition is clear, development and on-going improvement

of these skills is also part of a "transformative lifelong learning" process that encompasses both transferable and disciplinary knowledge and skills (Baker and Henson, 2010). As such, development (and recognition) of skills including learning, organisation, information literacy, oral and written communication, teamwork, critical thinking and leadership, also helps prepare students for further (*e.g.* postgraduate) study and/or research and other lifelong learning opportunities and challenges (Candy *et al.*, 1994).

Lastly, it is also recognised that within the wide scope of skill development, individual universities may prioritise the specific skills they seek to help their students develop through their courses. This may influence the skill development opportunities provided to students and hence the skills they recognise that they have developed or that they place value on. Of the two universities involved in this study, Monash University publicly communicates that its courses are underpinned by specific "Graduate Attributes", *i.e.* it aims to prepare its graduates to be globally engaged, responsible and effective, competent in cross-cultural interactions, ethical, critical, creative, innovative problem-solvers, able to apply research skills "to a range of challenges" and good communicators (Monash University, 2017). The University of Warwick, over the relevant research period, did not have an institutional policy on target graduate skills or attributes, which were left up to the individual departments. The Warwick chemistry department stipulates target skills *via* module principal aims and learning outcomes (University of Warwick, 2017). At first year, these include practical/laboratory skills, data processing/analysis, software/IT, problem-solving and numeracy. In second and third year, to these are added report writing, experiment design, information retrieval, teamwork, communication (including oral presentation), commercial awareness and job/career skills. These target skills and attributes provide a potential focus for evaluation and comparison of skills identified by students during the research.

Method

An exploratory research approach was applied, using an open-ended optional survey to collect qualitative data from undergraduates who were studying at least one chemistry subject at undergraduate level. The research was carried out as approved by the Monash University Human Research Ethics Committee (MUHREC) as per project 2017-0936-8426.

The paper-based survey collected written responses to three open-ended questions, as follows:

(1) In addition to developing detailed subject knowledge, what skills do you think you've developed so far in your degree?

(2) What skills would you like to develop during the remainder of your degree? [students prior to final year]

OR

What skills would you like to have developed to a greater extent during your degree? [Monash final year students]

(3) What do you think are the key skills employers are looking for, from graduates?

Students were invited to list up to five skills at each question, with five dot points provided in the space under each question. Demographic data was also collected from each participant:

- Gender
- Year of study (1st, 2nd, 3rd, 4th)
- Student type (Local/domestic or international)
- Degree type (Monash University students only; science single degree or double degree type)

A cross-sectional design was used, with year level data being collected at one point in time across different year cohorts.

Participants

In total, 990 undergraduates completed the survey, 774 of whom were from Monash University, Australia, and 216 of whom were from the University of Warwick, UK. A summary of participants by degree type, gender, student type (domestic/international) and year level is presented in Table 1. These demographics are representative of the relevant chemistry undergraduate cohorts.

Monash University students were enrolled in either a generalist Bachelor of Science (BSc) degree or a double degree incorporating BSc and another degree *e.g.* Arts, Engineering, Education *etc.* A BSc

Table 1 Research participants – demographics

University	Demographic	Number of responses	% sample
Monash	Total	774	
	Gender		
	Male	347	45
	Female	412	53
	Other/rather not say	15	2
	Student type		
	Local/domestic	712	92
	International	60	8
	Unspecified	2	
	Degree		
	Science	422	55
	Biomedical Science	101	13
	Science double degree	234	30
	Other	14	2
	Degree year level		
	One	475	61
	Two	217	28
	Three[a]	82	11
Warwick	Total	216	
	Gender		
	Male	118	55
	Female	97	45
	Unspecified	1	
	Student type		
	Local/domestic	194	90
	International	21	10
	Unspecified	1	
	Degree year level		
	One	64	30
	Two	71	33
	Three	81	37

[a] Monash year three includes science double degree students in third year or higher.

bachelor degree takes three years full time study to complete, whereas a double degree typically takes four to five years full time. Monash University first year BSc students study four subjects in each semester, of which chemistry can be just one. They choose a discipline major at second or subsequent year, but still study at least two disciplines in second year and potentially even third year. The number of students studying chemistry at Monash University is large in first year (over 1000), but decreases in subsequent years (to approximately 150 at third year), as students choose to specialise in one or two of a number of science majors.

By contrast, participants from the University of Warwick were all enrolled in a dedicated chemistry degree throughout their undergraduate study; either BSc Chemistry (three years) or MChem (Master in Chemistry, four years), with approximately 50% of the cohort in each stream and student enrolments fairly stable across first to third years (130–180).

All Monash University students were surveyed at the end of their academic year (October 2016). Surveys were distributed as hard copies either in a tutorial, laboratory class, presentation preparation or poster presentation session, as the course timetable allowed, and students were given time to complete it. The survey was introduced by a hard copy one page explanatory statement. Attendance was noted at all sessions in which the survey was offered, with some sessions compulsory (laboratory, poster presentation) and some not (first year tutorial, presentation preparation). 50%, 64% and 56% of the relevant cohort completed the survey at each year level (first, second and third year, respectively).

First and second year students at the University of Warwick were surveyed almost half way through the teaching period (end November 2016), with third year students at the start of the final month of the academic year (end April 2017). Unlike Monash students, all Warwick chemistry students in the same year of their degree study the same chemistry modules at the same time. All University of Warwick data was collected in a lunch break (with lunch provided) during full day compulsory laboratory classes with monitored attendance. 40%, 39% and 74% of each cohort completed the survey (first, second and third year, respectively).

The original research design incorporated surveying Warwick fourth year students as well. However, this group were very hard to reach and the resultant sample size was less than 30, so this group was excluded from further analysis.

Data analysis

All survey open-ended question responses were transcribed verbatim into Excel. This data was imported into NVivo 11 qualitative and mixed methods data analysis software, as three distinct data sets: one for each of the three open-ended questions asked in the survey.

Student responses tended to be concise, as they were asked to name skills and not define or describe a phenomenon or experience. Hence, after reviewing a subset of the data from each university, year level and question, an initial list of skill themes or 'codes' was created from the data. The qualitative coding process followed was as outlined by Creswell and Poth (2017), *i.e.* grouping the responses into categories, seeking evidence from the data for each code category, allocating a name and description for each code and then allocating pieces of text to each code category. Creswell & Poth outline that codes can be named using an "*in vivo*" approach (*i.e.* using the exact words of participants), using names created by the researcher that appropriately describe the information, using metaphors, and/or obtaining the names from relevant social science or other literature. In this study, the code names were created from the dominant words used by the respondents wherever possible or using words that appropriately summarised the respondents' words. One code list was created for all three questions, as there was significant overlap between responses to the three questions. This also allowed for later comparison between questions.

The initial code list was provided to two other chemistry education researchers along with a sample of survey responses to all three questions. The researchers allocated each survey response to a code or created new codes if they felt the initial codes were inadequate. Their assignment of skills to codes was then compared with the primary researcher's allocation, and, although 86% agreement was achieved, some slight modifications were made to the code labels and mode of allocation to maximise agreement. After further coding by the primary researcher and the two other chemistry education researchers, inter-rater reliability of 91% was achieved.

After all responses were coded within NVivo, the data for each of the three questions was downloaded into Excel using the NVivo 'matrix coding' function.

The theme codes created within NVivo included a number of sub-codes, such as types of laboratory, thinking/problem solving and communication skills. Once the data was exported into Excel, these were combined to give a set of main themes for final analysis and discussion. For the themes "communication skills" (which combined generic communication skills, writing skills and presentation or public speaking skills) and "thinking/problem solving skills" (which included miscellaneous thinking skills, problem solving, critical thinking and analytical skills), a notable number of respondents gave more than one response within each theme. It was decided to combine these sub-themes in order to simplify the analysis, however the ability to more deeply examine these was retained if needed.

A small number of responses were 'double-barrelled' and so were coded to more than one theme. *E.g.* "ability to take initiative and work independently" was coded as "initiative" and "independent working/thinking"; "communication/people skills" was coded as "communication" and "interpersonal/social" skills.

Some literature references combine organisational and time management together as a single skill (DEST; ACCI; BCA, 2002; Sarkar *et al.*, 2016). These were coded separately in this study due to the common occurrence of individual students writing both of these skills but on separate lines in their survey response, indicating many students considered these to be different skills. A list of the main themes that emerged are presented in Table 2.

The final data set (Fig. 1–5b and Table 4) is presented as a percentage of respondents in each group identifying a particular skill in response to each question. Only themes mentioned by

Table 2 Themes that emerged from undergraduate responses to the open-ended questions (includes only themes identified by greater than 5% of respondents in any cohort)

Theme (skill name or attribute)	Further details and/or examples
Application of knowledge	"How Chemistry can be applied to real life", "application to unfamiliar situation", "understanding of connection between studies and industry", "use knowledge learnt in units to solve real world problems", "application of chemical knowledge in the lab"
Attention to detail/accuracy/precision	"Performs tasks accurately", "ability to follow instructions carefully", "greater attention to detail"
Communication	Generic "communication skills", writing skills (reports, papers, essays *etc.*) and presentation or public speaking skills
Computer/IT/technology/software	Generic IT or technology skills, coding and/or specific program skills (*e.g.* Excel, Matlab, Java, python, modelling, media, mapping)
Creativity/innovation	"Thinking outside the box", "being innovative", "creative thinking", "free thinking/new ideas", "ability to formulate their own ideas"
Efficiency/productivity	"Efficient with time/work", "how to work more productively", "working at a fast pace", "usage/equipment efficiency"
Experiment development/design	"Developing own ideas rather than just following experiment", "being able to design your own pracs", "method development (less cookbook pracs)", "developing lab protocols"
Flexibility/adaptability	"Adaptability to new situations", "ability to adapt to change"
Independent working/thinking	"Ability to act independently", "able to work independently", "independence of thought"; "independence"
Independent learning/study	"Personal learning skills", "finding easier methods of learning", "independent study skills", "self-guided learning"
Initiative	"Using your initiative", "initiative and being proactive"
Interpersonal	"People skills", "interpersonal skills", "Social skills", "Interacting with new people effectively"
Job/career	Includes work experience; career/job knowledge; skills for finding a job (*e.g.* CV and interview preparation); generic "employability skills", "transferable skills", "industry skills" or "workplace related skills"; business knowledge/acumen
Discipline knowledge	Includes generic subject knowledge as well as knowledge of specific topics
Laboratory/practical/technical	Includes skills in using equipment/instruments, specific or generic lab or technical techniques/methods/procedures, confidence and independence in the laboratory, safe lab practices
Leadership	Predominantly 'leadership' but also includes people management
Literature searching/referencing	How to research literature, journal articles, databases or other information sources and/or how to appropriately reference/cite
Maths/quantitative	Mathematical, numeracy, computational and calculation skills
Data analysis/interpretation	"Ability to analyse and interpret data", "interpretation of data and results", "statistical analysis", "data analysis skills"
Organisational	Predominantly generic "organisational skills", but also includes planning, prioritisation, project management, multi-tasking
Research	"Independent research skills", "research techniques" "Research skills *e.g.* planning, doing, reporting, improving", "how to conduct a highly valid research project", "research both lab & literature based", "the ability to carry out research projects more independently"
Stress/pressure management	"Work under pressure", "ability to cope with pressure", "handling things well under stress"
Teamwork	Team work, group work, collaboration
Thinking/problem solving	Critical thinking; problem solving; analytical, quick, logical, abstract, spatial, deductive or lateral thinking or reasoning; reflection; memory
Time management	Includes punctuality
Personal attributes:	
– Confidence	"More confidence", "confidence in ability", "self-confidence"
– Enthusiasm/interest/positive attitude	"Passion for subject", "subject interest", "interest in field", "enthusiasm", "positivity"
– Responsible/reliable	Responsibility, accountability, reliability, ability/desire to finish work
– Other	Includes resilience, tolerance, loyalty, individuality, pragmatic, discernment, intuition, emotional intelligence, common sense, compassionate/empathy, sense of humour, courage, helpful, "nice person", risk-taker, personality traits

more than seven percent of respondents in any of the groups are presented in these figures and data tables.

Statistical analysis

Several statistical analysis techniques were used to determine whether there was a significant difference in skills named at each question by different demographic groups. All statistical tests were carried out using SPSS software. Non-parametric statistical techniques were used, as the data collected was categorical, rather than continuous *i.e.* for each skill theme identified, each student either fell into the category of naming that skill, or not naming that skill.

The non-parametric chi-square test for independence was used when testing for statistically significant differences between the percentage of students identifying a particular skill in one demographic group compared with another. One of the assumptions of the chi-square test is that at least 80% of cells have expected frequencies of five or more (Pallant, 2016). If this assumption was violated, Fisher's exact test was used, which is the standard alternative non-parametric test for independence when analysing small samples (although it is valid for all sample sizes) (Kim, 2017).

Table 3 The number of skills named by students at each question

Question	University	Mean	Median	25th percentile	75th percentile	Range
Skills developed so far in degree	Monash	3.1	3	2	4	6 (0 to 6)
	Warwick[a]	3.6	4	3	5	5 (1 to 6)
Skills would like to develop in remainder of degree	Monash[a]	2.2	2	1	3	8 (0 to 8)
	Warwick[a]	2.5	2	2	3	6 (0 to 6)
Skills employers are looking for, from graduates	Monash	3.1	3	2	4	7 (0 to 7)
	Warwick	3.3	3	3	4	5 (0 to 5)

[a] Denotes differences between universities in number of skills named are statistically significant, Mann–Whitney U test, $p < 0.001$.

Analysis of the number of skills students identified at each question was also carried out (Table 3). The non-parametric Mann–Whitney U test was used to test for statistically significant differences in the total number of skills identified by students in one demographic group compared with another (*e.g.* Monash *vs.* Warwick university). This test is the non-parametric version of the t-test and compares the medians of two independent groups. When comparing the total number of skills identified at different year levels, the Kruskal–Wallis test was used. This is the non-parametric alternative to a one-way ANOVA, allowing comparison between more than two groups.

Statistical tests were completed on university pair-wise comparisons of the percentage of students naming each skill theme within each question, as well as on gender pair-wise comparisons and year level comparisons within each university cohort. For all statistical tests completed comparing the percentage of skills identified by different groups, the level of significance used to identify a statistically significant difference was 0.01011, (which has been simplified to 0.010 in practice, in accordance with the number of decimal places reported by SPSS). Whenever a significant difference is noted in the results figures, tables or discussion comparing universities, year levels or gender, it is under the 0.010 threshold. The level of 0.01011 applied in this study is based on a 0.05 significance level per individual comparison, with a correction for 72 multiple comparisons (24 skills × 3 questions) per comparison type, based on a modified False Discovery Rate (modified FDR) method (Benjamini and Yekutieli, 2001; Narum, 2006). The latter method is an alternative to the Bonferroni correction for multiple comparisons. The conservative Bonferroni correction addresses the issue of significantly increased likelihood of 'false positive' tests (Type 1 error) when many comparisons are made on the same data set, but also results in a significant loss of power in detecting true differences. The modified FDR method applied offers a more powerful and "moderate approach to determining significance level" when multiple tests are required (Narum, 2006).

Exact statistical significance and effect size data is included in Table 4 for analysis of year level trends for each skill theme. For the chi-square test, Cramer's V is a measure of effect size. It is noted that where two degrees of freedom are involved, (as applies to the analysis of the year level data), a Cramer's V of 0.07 is considered small, 0.21 is considered medium and 0.35 is considered large (Kim, 2017).

Results and discussion

Students identified a variety of skills or attributes developed during their degree, desired from their degree or sought by employers (see Table 2). Although students were asked specifically to name "skills", some students expanded the questions to include any attribute or element they believed relevant. All of these points of view are included in the coded themes, which were not limited to a formal definition of 'skill', but rather represented all themes which were mentioned by more than five percent of the student cohort.

Number of skills identified by students

Table 3 summarises the mean and median number of skills named by students at each of the three open-ended questions, by university.

For both universities, students identified fewer skills they would like to develop in the remainder of their degree (median 2 skills named) compared with skills they have developed so far or skills employers are looking for (median typically 3). The reason for the lower number of responses on the skills students would like to develop going forwards is unknown. However, during data collection, there was a sense that students had never before thought about the skills they would like to gain from their degree and consequently, they found this question challenging.

Warwick students overall identified a larger number of skills as developed so far in their degree (median 4) than Monash students (median 3) and a slightly higher number of skills they would like to develop in the remainder of their degree (interquartile range 2–3, compared with Monash 1–3). It is possible that Warwick students' slightly higher median number of responses to these two questions could be due to feeling as if they had a little more flexibility with time when completing the survey (since they were responding during a laboratory lunch break whereas Monash students responded during class time), however we cannot be certain this is the reason for this difference.

Skills identified at each university

As shown in Fig. 1–3, the consistent skill themes identified by students from both Monash and Warwick universities in the survey were teamwork, laboratory/practical, communication, time management and thinking/problem solving skills. These were the top skills

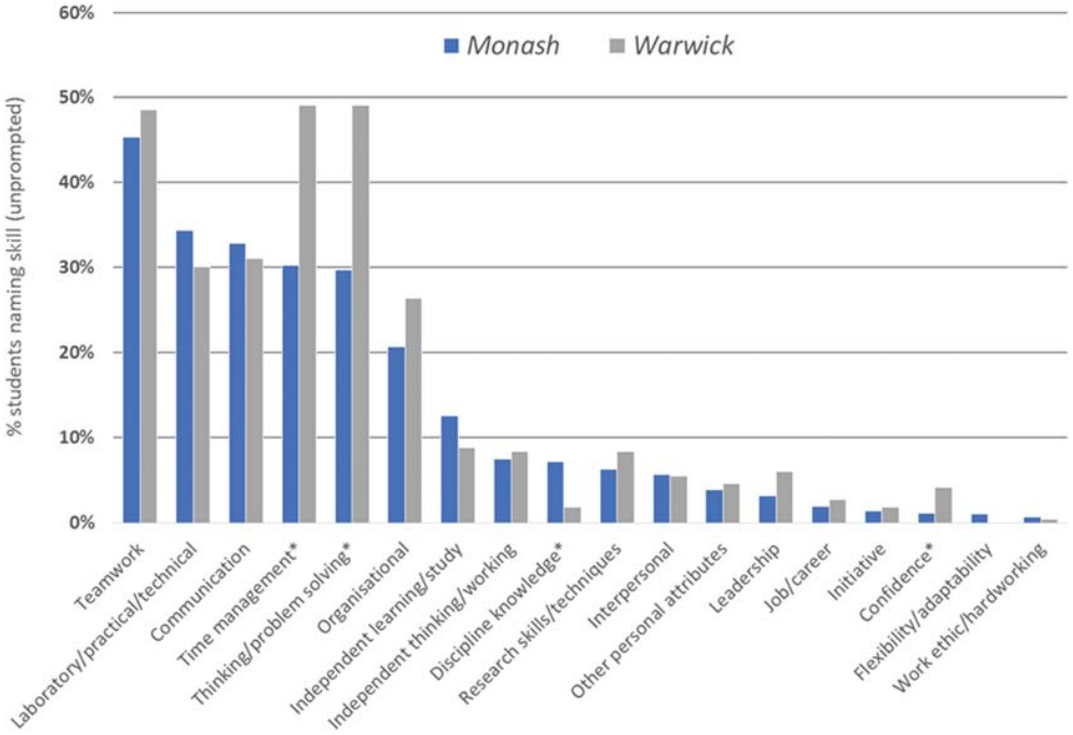

Fig. 1 Skills students believe they have developed so far in their degree, in addition to detailed subject knowledge, by university. * Denotes differences between universities that are statistically significant, chi-square test, $p < 0.010$.

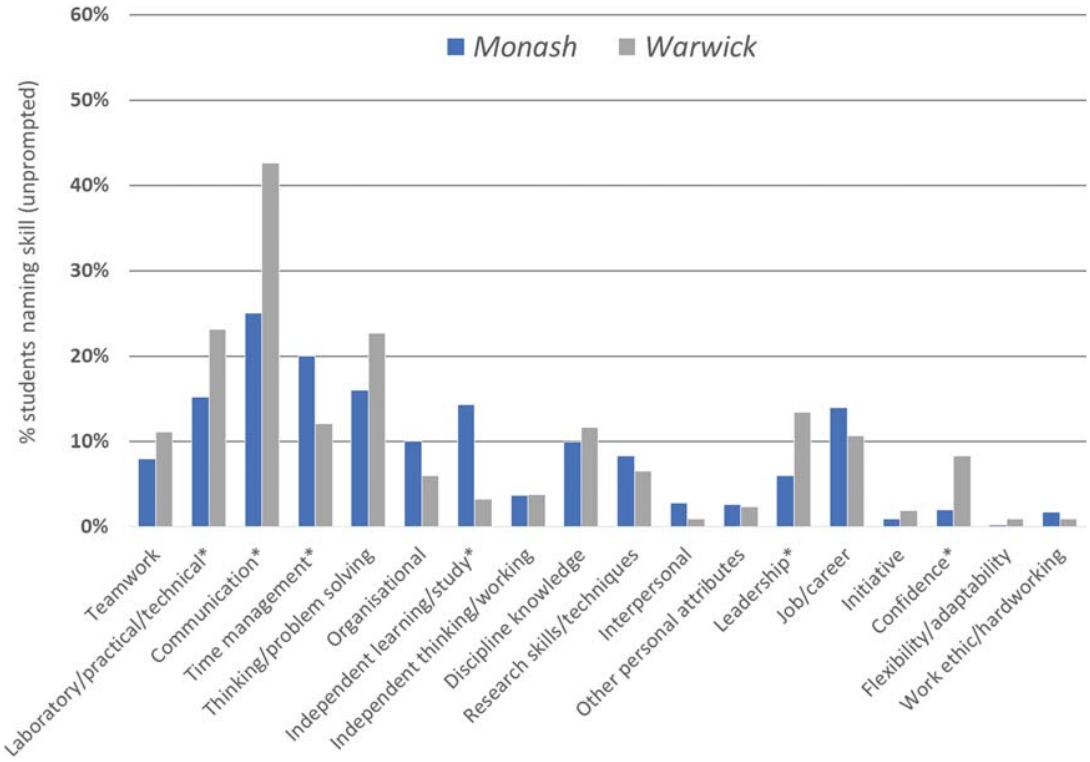

Fig. 2 Skills students would like to develop during the remainder of their degree, by university (or for Monash students enrolled in a third year Chemistry unit, skills they would like to have further developed during their degree). * Denotes differences between universities that are statistically significant, chi-square test, $p < 0.010$.

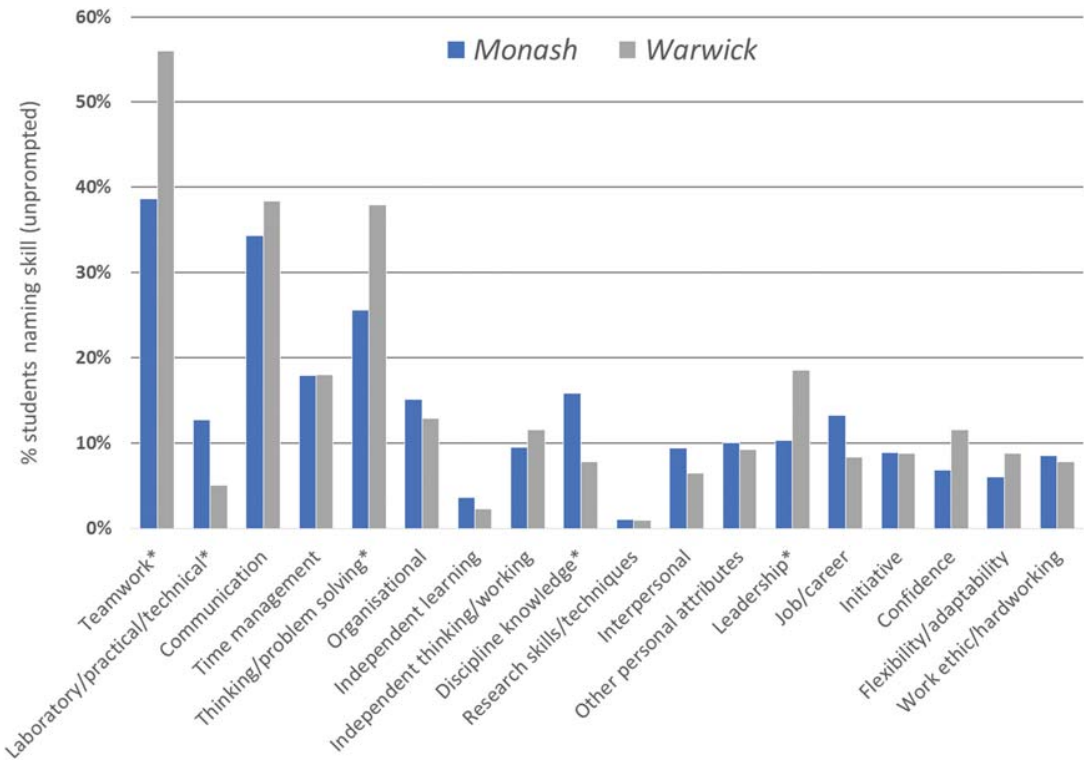

Fig. 3 Skills students believe employers are looking for, from graduates, by university. * Denotes differences between universities that are statistically significant, chi-square test, $p < 0.010$.

that 30–50% of undergraduates expressed they had developed so far in their degrees, followed by organisational skills (20–26% students).

The next highest skill attribution was independent learning/study skills, named by 13% of Monash students. All other skills were identified by fewer than 10% of students.

The skills identified as being developed by the two cohorts of university students are remarkably consistent given the difference in types of degrees in which they are enrolled. The only statistically significant differences are a higher proportion of Warwick students listing time management and thinking/problem solving skills, and a higher proportion of Monash students naming discipline knowledge.

The skills desired for further development (Fig. 2) included four of the top skills named as developed (communication, time management, thinking/problem solving, and laboratory/practical). Undergraduates obviously desired to further strengthen these key skills. However teamwork or organisational skills were not greatly prioritised for further gains, perhaps suggesting students felt they had had 'sufficient' development of the latter two skills. Although important to both cohorts, development of communication skills (especially writing and presentation) was sought even more strongly at Warwick than at Monash.

Job/career skills is significant in that it was identified as developed in their degree by only a few percent of each university cohort, whilst 11–14% desired further development. The specific types of job/career skills of interest to students were work experience, industry relevant practical and other skills, understanding of how problems/tasks from university transfer/relate to work, general employability/transferable skills, greater knowledge of job and career options, more industry information/focus, commercial/business awareness, professionalism, networking skills, 'job-finding' skills, and interview, CV and application preparation skills.

Whilst predominantly similar, a few differences were noted between the cohorts in the types of skills valued: more Warwick than Monash students were seeking the development of laboratory/practical skills, leadership and confidence, whilst more Monash undergraduates desired to develop independent learning/study and time management skills.

In terms of the skills employers are seeking from graduates (Fig. 3), students introduced a variety of personal attributes such as a strong work ethic, confidence, reliability and enthusiasm or interest. However, the strongest attributions to employers from both universities were three of the top five skills identified as developed (teamwork, thinking/problem solving and communication skills). It is noted, however, that a significantly higher proportion of Warwick students nominated the former two compared with the Monash cohort.

Other skills students believed employers desired were time management and organisational (again, in common with the skills identified as developed), as well as leadership skills. However, significantly more Monash students believed employers were seeking discipline knowledge and laboratory skills, whilst more Warwick students, in parallel with the skills they desired to develop further, nominated leadership.

Warwick students' lower employer attribution of discipline knowledge and laboratory skills is certainly not reflective of Warwick chemistry departmental priorities, as both of these skills are very frequently mentioned in module aims and learning outcomes. Although students weren't asked their career aspirations as part of this research, it is possible that the minor role of these two skills in Warwick undergraduates' responses may be related to the types of jobs desired by many of them, as non-chemistry employers will not require such skills. This was reflected in the recent research by Galloway (2017) amongst UK chemistry undergraduates wherein student ratings of useful/very useful for 'chemistry knowledge and instrumentation' were significantly higher when students indicated they were planning a 'chemistry occupation' compared with 'other occupation'. A Monash student explicitly reflected this view in her response:

"*If [employer is] science based, then [they] will want scientific skills (like good laboratory etiquette, good grasp of science knowledge)*".

It is important to note that in response to the skills employers are looking for, a few students wrote responses such as 'stand out candidates (attract attention)'. For example, one first year male student from Monash wrote:

"*It's not about key skills because everyone has the same skills. It's about doing volunteer stuff and other things and have experienced stuff that no one else has in order to separate yourself from the pack.*"

There is a sense in such comments that some students believe the successful job candidate will require that 'extra something' other than the transferable skills employers state they are seeking. Such students may be harder to engage in skills development initiatives.

The dominant skills identified by both Monash and Warwick undergraduates in part reflect their institutional/departmental priorities, with Monash University "Graduate Attributes" and the Warwick chemistry department modules both stipulating thinking/problem solving and communication skills, and with teamwork explicitly mentioned at Warwick and perhaps implied at Monash (being 'globally engaged, responsible and effective'). However, neither the Monash Graduate attributes nor the Warwick chemistry modules mention time management or organisational skills, whilst students clearly see development of and value in these skills. Likewise, Monash students expressed a strong desire for learning/study skills whilst this is not a stated institutional priority. The reason for Warwick students' greater emphasis on leadership and confidence is unknown, as it cannot be attributed to their module aims.

Whilst it is clear and pleasing that students are identifying and valuing some of the skills identified in institutional and departmental goals, there are some notable absences. Of the Monash Graduates attributes, Monash students did not identify cross-cultural competence, ethics, creativity or innovation as either valued or developed and research skills were only identified by a small percentage of students. Of the Warwick module aims and learning outcomes, data analysis, numeracy, software/IT, experiment design, information retrieval and commercial awareness were absent to any significant extent from student responses. Whether there was insufficient opportunity to develop some of these skills, or whether students simply did not notice them or appreciate their value, is not able to be determined from this study.

It is worth commenting that there is often a congruence in this study between the skills students' believe employers are seeking and those skills they state they have developed, with skills desired for further development at times acting like a moderator (*i.e.* if the percentage of students identifying employers are seeking the skill is significant, but the proportion of students identifying the skill as developed is low, the proportion of students desiring to develop the skill tends to be notable). For example, a moderate to high percentage of students recognise employers are seeking communication, teamwork, thinking/problem solving, time management and organisational skills and many students identify they have developed each of these skills. Likewise, at the other end of the scale, skills such as maths/quantitative, computer/IT and creativity/innovation are identified by very few students (6% or less) as both desired by employers and developed during the degree. Leadership skills at both Monash and Warwick illustrate the moderating factor of desiring the skill *e.g.* 19% of Warwick students identified employers are seeking this skill, 6% identified they have developed the skill and 13% desired to further develop this skill during their degree. Confidence amongst Warwick students follows the same pattern of desiring the skill acting as a moderator, as do interpersonal skills and independent thinking/working at both universities and job/career skills and discipline knowledge at Monash.

Laboratory/practical skills do not follow this trend. It is named as both developed and desired to further develop by a notable portion of students but not highly rated in the responses to skills employers are seeking, especially at Warwick. Research skills/techniques parallel laboratory/practical skills in this way, with 6–8% students both noting them as developed and desiring their further development but almost no students identifying them as an employer priority. As discussed above, this may reflect career choice for some students (and the recognition/perception that non-science employers will not require laboratory or research skills) whilst simultaneously acknowledging the need to succeed at such skills now in order to perform well in the degree.

Some other skill development desires also seem to reflect this "need now" bias, such as independent learning and study skills, desired by Monash students (for the successful completion of their degree), but not identified as a skill employers are seeking. Job/career skills also seem to fall into this category for Warwick students, who will need job identification, application and interview skills to gain employment when they complete their degree.

Three skills identified by a small number of students at both universities as desired by employers (initiative, flexibility/adaptability and work ethic/hardworking), do not fit the above trends of either parallel recognition of employer priority and degree development (with desire for development a potential moderator) or a 'need now' bias: 6–9% students at both institutions state employers are seeking these skills, whilst only 1–2% students identify them as developed and desire their further development during the degree. Why this is so is not clear, but it is possible that some students simply don't see development of these attributes as part of a degree, but rather feel they are more

likely to be gained elsewhere, such as through extra-curricular activities (Tomlinson, 2008).

An implication of the link between student identification of a skill as an employer priority and their recognition of development of the skill (observed above for ten skills at both institutions and two additional skills at individual institutions) and the 'need now' bias (observed in four instances), is that if students don't recognise employers are strongly seeking a specific skill and/or the immediate benefit of developing the skill, they may be less likely to desire its development and be conscious of the development when it occurs. This reflects the relationship discussed in the literature between recognition of value, motivation and learning, with Pintrich (2003) stating "higher levels of value motivate students" and "it matters whether students care about or think the task is important in some way".

Tymon (2013) in his research into the attitudes of business undergraduates to employability skills development concludes that some first and second year students in particular may lack engagement with skills development activities incorporated within the degree, which will limit their learning. He suggests universities could more clearly communicate the benefits of employability skills to students and make curriculum-embedded skills development tasks much more obvious. Certainly, this research adds some support to the view that there may be a relationship between recognition of value, awareness of and motivation towards skill development. It is also possible that for some students, the link may occur in the other direction; noticing skill development, with reflection, may lead to the recognition that the skill has value in terms of future employment, with Pintrich (2003) also observing that cognition can lead to motivation.

Year level comparison

Student responses to each of the survey questions were further analysed by year group in order to try to understand whether skill recognition and value was consistent throughout the degree or whether there were certain year levels where perceived skill value and/or development were more dominant. Such year level analysis could provide an opportunity to relate student skill recognition to curriculum design, to help identify potential opportunities for further skill communication or enhancement at specific year levels. It was also desired to know the views of third year students, many of whom will shortly graduate and seek employment, to understand to what extent these students are aware of employer priorities and their own skill development at this critical transition point.

The most notable finding when reviewing student responses across year levels (Table 4) is that, despite some differences in specific percentages, the core skills identified by both Monash and Warwick students as developed during their degree remain the same for each year *i.e.* teamwork, laboratory/practical, communication, thinking/problem solving, organisation and time management; with the addition of independent learning/study skills at some year levels. Other skills were rarely identified by students at any year level and whether this is because they haven't been developed significantly or whether students just haven't noticed their development, cannot be unequivocally determined by the current research.

Whilst acknowledging the limitations of the cross-sectional design (see Limitations section), there are some interesting trends across year levels for some skills. At Monash, the percentage of students naming independent learning/study skills as both developed and desired decreased from first to third year, as did the percentage of students desiring further time management and organisational skills. At the same time, higher order skills were named as developed and desired more frequently. These results may indicate that some first year Monash students appear initially focused on their ability to learn and study independently, and manage themselves and their time, perhaps reflecting the shift from small well-supported classes at school to large cohorts and self-direction at university. However, it's pleasing to see this absorbs less of students' attention at higher years. Instead they increasingly recognise progression in, and/or desire for, their scientific and related skills (research, method design, data analysis and laboratory skills) as well as development of their thinking and communication skills. This recognition of higher order skill development in later years also parallels undergraduates' increasing discipline specialisation in the Monash science degree structure, with first year incorporating a basic introduction to the subject, and later years involving more in depth study and technical skills. More second and third year students also felt employers were seeking laboratory/practical skills from graduates than first year students. This may well reflect the increasing specialisation of Monash higher year students in chemistry as a chosen discipline major and associated interest in chemistry-related jobs.

Amongst Warwick students, communication was the only skill identified as developed to a different extent by year level; showing a marked increase (large effect size). When broken down into its constituent sub-themes, (generic "communication", writing and presentation/public speaking), each of these also showed a statistically significant increase with year level. The percentage of Warwick students noting oral presentation and generic communication skills jumped notably between second and third year, whilst the proportion of students identifying writing skill development increased between first and second year.

The difference in skill progression by year level at Warwick compared with Monash is likely reflective of the different course structure. Before commencing their degree, Warwick students have to meet chemistry and maths pre-requisites and specialise in chemistry from first year. Hence chemistry-related cognitive and scientific skills such as laboratory skills and data analysis remain a focus from the very beginning of the course and continue to be addressed throughout. In terms of other employability skills, the first year of the course is primarily focused on discipline knowledge acquisition and laboratory skills. The concept of transferable skills is not introduced into the curriculum until second year with a "Key Skills" module, which includes assessments focused on searching the

Table 4 Skills identified by students by year level at each question. (Significance level and effect size as per chi-square or Fisher's exact test, 2 df). Grey highlighting indicates a statistical significance <0.010 for the relationship between skill and year level

	% students identifying each skill as:														
	developed during their degree					desired for further development					sought by employers				
Student year level:	1	2	3	sig. level	Effect size	1	2	3	sig. level	Effect size	1	2	3	sig. level	Effect size
Monash students															
Teamwork	48%	40%	48%	0.14	0.07	10%	6%	1%	0.03	0.10	37%	42%	37%	0.49	0.04
Time management	32%	30%	20%	0.07	0.08	24%	15%	12%	**<0.001**	**0.12**	19%	20%	7%	0.03	0.10
Laboratory/practical/technical	31%	38%	45%	0.02	0.10	12%	20%	21%	**0.007**	**0.11**	9%	18%	20%	**<0.001**	**0.14**
Communication	28%	42%	38%	**<0.001**	**0.14**	24%	28%	19%	0.30	0.06	31%	38%	41%	0.08	0.08
Thinking/problem solving	24%	40%	37%	**<0.001**	**0.16**	16%	19%	8%	0.08	0.08	25%	25%	29%	0.72	0.03
Organisational	22%	18%	21%	0.39	0.05	**13%**	**6%**	**5%**	**0.005**	**0.12**	17%	12%	10%	0.09	0.08
Independent learning/study	16%	8%	4%	**<0.001**	**0.14**	18%	8%	9%	**<0.001**	**0.14**	4%	3%	4%	0.96	0.01
Independent thinking/working	9%	5%	6%	0.19	0.07	4%	3%	4%	0.96	0.01	11%	6%	11%	0.19	0.07
Discipline knowledge	7%	8%	5%	0.68	0.03	12%	8%	3%	0.02	0.10	16%	16%	13%	0.79	0.03
Interpersonal/social	6%	6%	2%	0.36	0.05	3%	1%	3%	0.36	0.05	10%	9%	10%	0.93	0.01
Research skills/techniques	4%	7%	17%	**<0.001**	**0.16**	6%	11%	13%	0.04	0.09	1%	1%	2%	0.19	0.06
All other personal attributes	4%	5%	2%	0.69	0.03	3%	2%	0%	0.15	0.07	10%	11%	7%	0.64	0.03
Experiment/method design	3%	1%	2%	0.50	0.04	1%	5%	8%	**<0.001**	**0.15**	0%	0%	1%	0.11	0.10
Leadership	3%	5%	0%	0.07	0.08	7%	5%	4%	0.35	0.05	12%	7%	7%	0.06	0.09
Computer/IT/tech/software	3%	3%	4%	0.85	0.02	1%	6%	1%	**<0.001**	**0.15**	2%	4%	5%	0.13	0.07
Stress management	2%	5%	4%	0.16	0.07	3%	0%	0%	0.02	0.11	1%	1%	1%	0.89	0.02
Job/career	2%	2%	1%	0.86	0.02	13%	15%	18%	0.36	0.05	14%	13%	10%	0.61	0.04
Flexibility/adaptability	1%	0%	0%	0.27	0.06	0%	0%	0%	1.00	0.03	6%	6%	5%	0.87	0.02
Initiative	1%	2%	0%	0.50	0.04	0%	1%	3%	0.12	0.07	8%	10%	10%	0.69	0.03
Maths/quantitative	1%	1%	2%	0.67	0.04	1%	3%	0%	0.12	0.08	0%	1%	1%	0.14	0.07
Confidence	1%	1%	0%	0.78	0.04	2%	2%	1%	0.94	0.02	7%	8%	4%	0.45	0.05
Data analysis & intepretation	0%	4%	9%	**<0.001**	**0.18**	0%	1%	3%	0.12	0.07	1%	2%	0%	0.21	0.07
Work ethic/hardworking	0%	1%	0%	0.32	0.06	2%	1%	1%	0.60	0.04	10%	6%	5%	0.14	0.07
Enthusiasm/interest	0%	0%	1%	0.11	0.10	1%	2%	3%	0.19	0.07	8%	3%	6%	0.05	0.09
Warwick students															
Teamwork	42%	49%	53%	0.42	0.09	8%	11%	14%	0.52	0.08	45%	63%	58%	0.10	0.15
Time management	42%	54%	51%	0.40	0.09	9%	6%	20%	0.02	0.19	13%	14%	26%	0.07	0.16
Laboratory/practical/technical	31%	25%	33%	0.57	0.08	30%	14%	26%	0.08	0.16	6%	4%	5%	0.92	0.04
Communication	6%	30%	52%	**<0.001**	**0.40**	23%	49%	52%	**0.001**	**0.25**	19%	52%	42%	**<0.001**	**0.28**
Thinking/problem solving	59%	45%	44%	0.15	0.13	38%	20%	14%	**0.002**	**0.24**	50%	32%	33%	0.07	0.16
Organisational	17%	34%	27%	0.09	0.15	8%	3%	7%	0.40	0.09	13%	13%	14%	1.00	0.01
Independent learning/study	9%	4%	12%	0.22	0.12	3%	1%	5%	0.51	0.08	0%	0%	6%	0.02	0.20
Independent thinking/working	9%	6%	10%	0.64	0.07	3%	6%	2%	0.67	0.07	6%	10%	17%	0.11	0.15
Discipline knowledge	5%	0%	1%	0.11	0.14	23%	11%	2%	**0.001**	**0.27**	8%	11%	5%	0.36	0.10
Interpersonal/social	5%	3%	9%	0.29	0.11	0%	3%	0%	0.20	0.14	5%	3%	11%	0.09	0.15
Research skills/techniques	5%	13%	7%	0.24	0.12	5%	8%	6%	0.70	0.06	0%	3%	0%	0.20	0.14
All other personal attributes	8%	4%	2%	0.31	0.10	3%	1%	2%	0.87	0.05	19%	7%	4%	**0.006**	**0.22**
Experiment/method design	0%	0%	0%	NA	NA	0%	0%	2%	0.34	0.13	0%	0%	0%	NA	NA
Leadership	3%	3%	11%	0.05	0.17	16%	14%	11%	0.71	0.06	17%	27%	12%	0.07	0.16
Computer/IT/tech/software	2%	11%	6%	0.07	0.16	5%	7%	9%	0.65	0.06	2%	4%	4%	0.72	0.06
Stress management	9%	6%	5%	0.54	0.08	3%	0%	9%	0.02	0.18	5%	0%	5%	0.19	0.13
Job/career	2%	4%	2%	0.68	0.07	9%	15%	7%	0.27	0.11	16%	4%	6%	0.04	0.17
Flexibility/adaptability	0%	0%	0%	NA	NA	2%	0%	1%	0.75	0.07	14%	10%	4%	0.09	0.15
Initiative	2%	1%	2%	1.00	0.04	2%	3%	1%	0.84	0.05	3%	14%	9%	0.08	0.15
Maths/quantitative	2%	7%	9%	0.20	0.13	6%	7%	2%	0.40	0.09	6%	3%	2%	0.44	0.09
Confidence	5%	3%	5%	0.84	0.05	5%	8%	11%	0.42	0.10	14%	13%	9%	0.60	0.07
Data analysis & intepretation	3%	1%	6%	0.29	0.11	6%	0%	2%	0.09	0.15	2%	0%	1%	0.76	0.07
Work ethic/hardworking	0%	0%	1%	1.00	0.09	2%	0%	1%	0.75	0.07	5%	11%	7%	0.38	0.10
Enthusiasm/interest	0%	0%	0%	NA	NA	3%	0%	0%	0.09	0.15	9%	6%	4%	0.35	0.10

literature, writing a journal article, preparing a poster and presenting orally.

However, the second year data was collected prior to students completing the presentation skills component of this module, which is consistent with the low attribution to this skill by second year students and the improvement in third year. In addition, a few third year Warwick modules incorporate an oral or poster presentation as part of the assessment process. By contrast, writing is required of students in the form of laboratory reports at all year levels, although at the time of surveying, Warwick first year students had only completed half of the academic year and hence had had limited opportunity to do so. However, a year later, second year students felt they had had significantly more opportunity to develop writing skills.

By comparison, Monash students are also introduced explicitly to transferable skills in the second year during a compulsory ''Scientific practice and communication'' unit, which incorporates assessments focused on literature searching, writing a press release and literature review and a group oral presentation. In addition, Monash science undergraduates tend to be exposed to a range of other oral and written communication tasks across year levels in various subjects, including chemistry, *e.g.* first year chemistry students give a group presentation on a demonstrated laboratory experiment and second year analytical chemistry students give a moot court oral presentation *etc.* This may be a contributor to the greater attribution of ''communication skills'' by Monash students at first and second year and the reduced variation by year level compared with Warwick students.

Interestingly, a few skills declined in demand for further development at increased year level at Warwick (discipline knowledge and thinking skills), suggesting perhaps that students were satisfied with their development in each of these areas.

It is noted that Warwick undergraduates continue to show a strong thirst for further communication skills (especially presentation skills) throughout their degree, despite increasing development. This fits with their significantly increased belief at higher year levels that employers are seeking this skill. Time and stress management were also more highly prioritised for development by Warwick third year students than prior years. This could be because at the time of surveying, Warwick students had just commenced a month long intensive practical program wherein they spend every day in the laboratory, and students indicated anecdotally that time management was a key factor in this element of the course.

Finally, it might be expected that skills consistent with the Monash graduate attributes are better recognised as students approach graduation. This appeared to be the case for thinking/problem solving, communication and research skills. However, it was not so for cross-cultural competence, ethics, creativity or innovation, which remained absent at third year in terms of both development and value.

At Warwick, the increased recognition and value of communication skills at second and third year reflected the addition of these skills in module aims at these year levels. However, other skills (*e.g.* experiment design, commercial awareness and information retrieval) were not noted significantly at higher levels, despite their explicit expression in the modules. Numeracy and data analysis were also poorly recognised and valued at each year level despite their prevalence in Warwick module learning outcomes across the course. This emphasises the need for further communication of some skills beyond their inclusion in graduate attributes or learning aims in order for students to appreciate their value.

Gender differences

The impact of gender on student responses was investigated, as significant differences by gender could help inform any future interventions aimed at increasing student recognition of skill development and value. However, as for year level, the most notable result from the gender comparison (Fig. 4a, b and 5a, b), was that the core skills identified as developed and valued remained the same across both genders.

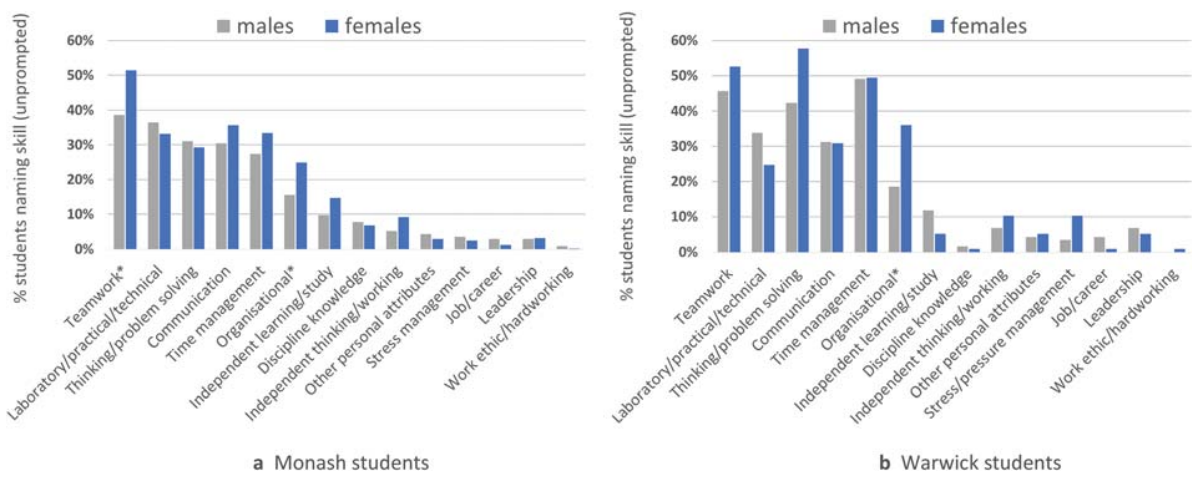

Fig. 4 (a and b) Skills developed so far in degree by males and females. * Denotes a significant difference between % males and % females identifying skills (chi-square test, $p < 0.010$).

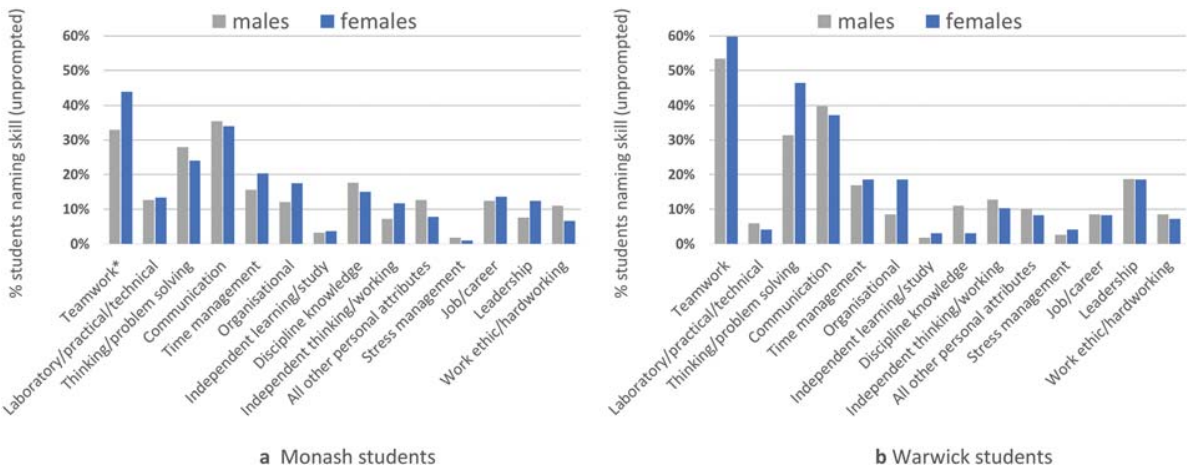

Fig. 5 (a and b) Skills employers are seeking from graduates by males and females. * Denotes a significant difference between % males and % females identifying skills (chi-square test, $p < 0.010$).

In terms of specific gender differences, at Monash, a higher proportion of female students than males both recognised development of teamwork and believed it to be more valuable to employers; and at both institutions, more females than males recognised they had developed organisational skills. The latter effect may be because females more readily notice opportunities to develop their organisational skills and/or because they feel they have made greater progress in the development of this skill during their degree.

In terms of skills desired for development in the remainder of their degree, the only gender difference achieving statistical significance was a greater proportion of Monash female students than males wanted to develop their time management skills (24% *vs.* 15%).

Comparison with employer views

Table 5 summarises the views of both employers and graduates as to the skills required from graduates employed in chemistry, science/STEM and general occupations, as reported in the literature. These employer and graduate views were obtained *via* a variety of methods including quantitative surveys (Hanson and Overton, 2010; Sarkar *et al.*, 2016), interviews and/or focus groups (DEST; ACCI; BCA, 2002; Lowden *et al*, 2011) or a combination of interviews and quantitative surveys (Purcell *et al.*, 2008; Deloitte Access Economics, 2014).

Although the methodologies used to obtain the data varied, the views shared in these studies provide an important qualitative indication of what is likely to be required of chemistry graduates if they wish to obtain employment and succeed in the workplace. In the following section, the employer/graduate views will be compared with the skills Warwick and Monash chemistry/science students say they've gained during their degree and their perceptions of what employers are looking for. It is not intended to make a detailed quantitative analysis of the employer and graduate research summarised in Table 5, but simply to ascertain whether students are likely to recognise the skills expected to be demonstrated during the job application process and in the workplace. Whilst further discussion and probing *via* focus groups or interviews may have led to students identifying more skills in this study, the brief survey used was deliberately designed to ascertain whether students readily, and without intervention or prompting, recognise the requisite skills. This mimics the situation at Monash and Warwick universities at the time of the research; other than an introduction to the concept of transferable skills in one second year unit, there was typically no intervention, prompting or additional discussion of these skills or individuals' development of them, before students leave university and apply for employment or postgraduate study.

As expected, laboratory/technical skills and discipline knowledge were valued by industry employers of chemistry and STEM graduates and the graduates themselves that were employed in relevant scientific employment, but they were not required by general employers. However, somewhat surprisingly, laboratory/technical skills were valued by chemistry graduates to a lesser extent than a range of other transferable skills. This underscores the importance of the latter skills, regardless of the type of work involved.

In terms of specific transferable skills, each employer and graduate research source summarised in Table 5 stipulate teamwork, communication, thinking/problem solving and organisational/time management skills are sought by employers and needed by chemistry/science graduates in the workforce, regardless of the type of occupation (scientific or general). It is really pleasing to see that these five skills are in the list of top six skills recognised by students as both developed in their degree and desired by employers, at both institutions.

However, once we move beyond these five skills, student recognition of the value employers place on other skills is poor. For example, all employer references except one, and both graduate references, list numeracy skills as valuable, but only 1% of Monash and 5% Warwick students stated employers are looking for numeracy or data analysis skills, and very few students noted the development of either of these skills (4%

Table 5 Summary of skills identified as important or valuable in the workplace by employers and chemistry/science graduates

	Employers' views					Graduates' views	
Type of graduates/employment	Chemistry [by industry employers]	Chemistry [by general employers]	STEM	All	All	Chemistry	Science
References	(Purcell *et al.*, 2008)	(Purcell *et al.*, 2008)	(Deloitte Access Economics, 2014)	(Lowden *et al.*, 2011)	(DEST; ACCI; BCA, 2002)	(Hanson and Overton, 2010)[b]	(Sarkar *et al.*, 2016)[b]
Skill or attribute							
Teamwork	X	X	X	X	X	X	X
Thinking/problem solving[a]	X	X	X	X	X	X	X
Independent learning		X	X		X	X	X
Communication – verbal	X	X	X	X	X	na	X
Communication – written	X	X	X	X	X	X	Y
Communication – presentation skills		X				X	na
Organisation/time management	X	X	X	X	X	X	X
Commercial/business awareness	X	X	X	X		na	Y
Initiative				X	X	na	X
Flexibility/adaptability	X	X		Y	X	na	X
Leadership/management	X	X		X		na	X
Practical/technical	X		X			Y	Y
Discipline knowledge	X		X			Y	Y
Interpersonal/social	X	X	X	X	X	na	na
Creativity/innovation			X	Y	X	na	na
Computer/IT/technology				X	X	na	Y
Research (generic)	X	X					Y
– Information retrieval					X	X	X
– Designing experiments						Y	
Numeracy	X	X		X	X	X	Y
Relevant work experience		X	X	X		na	na
Work ethic/hardworking		X			X	na	na
Motivation	X			X	X	na	na
Enthusiasm/interest				Y	X	na	na
Tenacity/commitment				X	X	na	na

[a] Analytical skills, critical thinking skills, problem solving. X = broad conclusion across all employers; Y = mentioned by multiple employers but not broad conclusion. [b] Conclusions from quantitative survey involving a specific list of skills; Y = 50–74% of graduates, X $\geq$ 75% graduates stated skill is useful/very useful in their job; na = not asked.

Monash and 9% Warwick students, when the skill themes maths/quantitative and data analysis are combined).

Other skills valued by the majority of employer and graduate research sources in Table 5 were independent learning, commercial/business awareness, flexibility/adaptability, leadership, interpersonal/social and research skills. Being able to work and think independently was recognised by some students in this study as both developed and valued by employers (8–12%), but independent learning and research skills were identified by very few students as sought by employers, and as developed by just 7–12% students.

Commercial/business awareness was not identified by students as either developed or as an employer priority.

More Warwick students perceived the value of leadership (19%) than Monash students (10%) but only a few students identified leadership as developed. Likewise, flexibility/adaptability and interpersonal skills were rarely recognised as developed and only occasionally as valued (6–9%).

Of the remaining attributes summarised in Table 5, initiative, computer/IT skills, creativity/innovation and relevant work experience were identified by approximately half of the employer/graduate sources. Initiative was named as sought by employers by about 10% students but as developed in their degree by almost no students. Creativity/innovation likewise was not identified as developed during their degree, and just a few students realised employers value it (4–6%). Computer/IT/software skills were also rarely named as developed at each university and as employer priorities.

In summary, a reasonable number of undergraduate students studying chemistry recognise employers value teamwork, communication, laboratory/technical, thinking/problem solving and time management/organisational skills and that they are developing these skills during their degree.

However, most students studying chemistry at Warwick or Monash do not readily identify that employers are seeking other transferable skills including numeracy/data analysis, independent learning, commercial/business awareness, flexibility/adaptability, initiative, creativity/innovation and computer/IT skills. Likewise, they are unlikely to identify they have developed these skills during their degree, without prompting. Whether this is due to a lack of opportunity to develop these skills or whether it's because of a lack of recognition they have developed these skills during their degree, cannot be concluded from this research. But the fact that when prompted with a list, a majority of recent chemistry or science graduates respond that they developed a much wider range of transferable skills during their degree including numeracy, data interpretation, independent learning, information retrieval, research, initiative, flexibility/adaptability and computer/IT skills

(Hanson and Overton, 2010; Sarkar *et al.*, 2016) and final year undergraduate science students stated they had developed quantitative skills (Varsavsky *et al.*, 2014), suggests that lack of recognition of development may be a significant contributing factor.

Limitations

A limitation of the study was that student survey response rates varied across year levels and universities, from 39% to 74% of each cohort. Although significant numbers of completed surveys were still achieved for each year level at each university, we cannot be certain that the views related to lower response rates (*e.g.* Warwick first years and second years) were entirely representative of their year level cohort.

Another limitation was that the cross-sectional design methodology used means that it is impossible to be certain that differences observed between year levels are due to the year level of study, as they may have been caused by differences between the respective cohorts.

An additional limitation was that students were asked to name up to five skills at each question (rather than an unlimited number of skills). The purpose of providing a target number of responses was to encourage students to write more than just one or two skills at each question. Five was chosen so that this target was not too daunting for students. Whilst some students chose to write more than five skills for each question (Table 3), it is possible that limiting the guidance number to five may have prevented some students from listing additional skills they had thought of. However, as a significant majority of students at both universities only identified up to four skills at each question (71–78% for skills developed, 90% for skills desired to further develop and 80–85% for skills sought by employers), the majority of students did not appear to be limited by the suggestion of listing five skills. In addition, if all skills were equally recognisable to students, they would be expected to appear to a consistent extent in responses, irrespective of the suggested per question skill limit. As this was not the case, the data would suggest that those skills much less frequently identified by students were less easily recognised and/or valued by them.

A further limitation was a difference between year levels at Monash in the context in which students were surveyed. All first year students were surveyed during a chemistry tutorial, whereas second and third years were in a mixture of contexts (tutorial, poster session or laboratory), although at least two thirds of the higher years were seated in a laboratory when responding. It is possible that the context biased some responses to the skills questions, with a laboratory context perhaps prompting the idea of development of laboratory skills despite the question wording asking for students to respond on "what skills you've developed so far during your degree". Although some influence of context cannot be ruled out, given teamwork skills was the most common response theme at a consistent rate across year levels (48% at both first and third years) and recent research amongst Monash science undergraduates indicates that "working in groups during a laboratory" was the most common university curriculum context in which students indicate they develop teamwork (Wilson *et al.*, 2017), it is felt that first year responses were probably reflective of skill development inclusive of laboratories. In addition, laboratory/practical skills were still mentioned more often by first year students than thinking/problem solving skills, again despite the survey context of a tutorial, which also supports this view.

Summary and conclusions

When undergraduates studying chemistry at an Australian and UK university were asked which skills they have developed so far in their degree, without prompting with a pre-prepared skill list, students were able on average to name three (Monash) or four skills (Warwick). Responses reveal a strong consistency in skills recognised across both universities, with 30–50% students identifying they had developed five key skills: teamwork, thinking/problem solving, time management, laboratory/practical and communication skills, with a further 20–27% identifying organisational skills and around 10% identifying independent learning/study skills.

At Monash, students were more likely to name independent learning/study skills at first year, and higher level skills with increasing year level (communication, thinking/problem solving, laboratory skills, research skills/techniques and data analysis/interpretation). The proportion of Warwick students identifying they had developed communication skills markedly increased with year level.

Students were most likely to desire further development of four of the key skills recognised as developed (*i.e.* communication, laboratory/practical, thinking/problem solving, and time management), as well as job/career skills to help them prepare for the job identification and application process and a successful transition to the workforce. A high proportion of third year Warwick students (52%) were seeking further communication skill development (especially presentation skills), suggesting they may welcome more opportunities in the curriculum to develop such skills. In contrast, teamwork skills were highlighted as a development need by few students at Monash, perhaps indicating they may feel they already have sufficient exposure to this skill area. Likewise, the proportion of students desiring further discipline knowledge was low at third year at both universities, suggesting many students were satisfied with this element near the end of their degree and prioritised other areas for further enhancement.

The skills recognised and valued were very consistent across genders at both universities, with the only statistically significant differences detected being a higher proportion of females than males identifying they had developed organisational skills at both universities, more Monash females recognising teamwork as both developed and desired by employers and a greater proportion of Monash females than males wanting to develop their time management skills.

In terms of which skills employers are seeking from graduates, students were able on average to name three skills. The strongest

responses were teamwork, communication and cognitive skills (25–58% students) followed by time management (18%) and organisational skills (14% students). As these reflect some of the key transferable skills sought by employers (as reported in the literature), it is really pleasing to see many students not only have an accurate view of the need for these skills, but also are recognising their development during their studies.

However, research amongst chemistry, science and general employers suggests the majority of employers are seeking additional skills from graduates, particularly numeracy (including data analysis), independent learning, commercial/business awareness, flexibility/adaptability, leadership, interpersonal and research skills. In this study, unprompted student recognition of both the value placed on these specific skills by employers, and their development within the curriculum, was poor. Likewise, initiative, computer/IT skills and creativity/innovation were identified by many employers, but not recognised or identified as developed by most students.

Student-recognised development of and value placed on thinking/problem solving, communication and teamwork skills overlapped with explicit institutional or departmental skill priorities in the form of graduate attributes (Monash) or module aims and learning outcomes (Warwick), with the addition of laboratory skills for Warwick. However, Monash students did not identify other graduate attributes as developed or of value (cultural competence, ethics, creativity and innovation) and likewise Warwick students did not value some of the prevalent module learning outcomes (numeracy, data analysis, experiment design and software/IT skills). Hence, expressing the latter skills as institutional or module aims may be insufficient to raise student awareness of and/or convince them of their value.

Our conclusion is that undergraduates studying chemistry are most likely to value and recognise development of teamwork, communication, thinking/problem solving, organisational, time management and laboratory/practical skills. However students need assistance with both recognising they are developing other skills sought by employers at university and understanding their importance. In particular, universities can significantly benefit undergraduates studying chemistry and science by highlighting the value of and instances when these students have the opportunity to strengthen numeracy (including data analysis), independent learning, commercial/business awareness, interpersonal, research, computer/IT and creativity/innovation skills, as well as flexibility/adaptability and initiative. Where lacking, it would be highly desirable to offer opportunities within the curriculum to build and use these skills and attributes and highlight when this is occurring.

By increasing students' understanding of the value of these transferable skills, and the opportunities available to improve them during their degree, students will be more likely to be motivated to develop them, recognise the need to highlight them in the job application process and transfer them to the workplace, postgraduate study or further research roles. Increasing opportunities to develop, recognise and value these skills should strengthen students' ability to meet employer needs and widen the pool of jobs they can apply for, which may be critical for their success in a highly competitive job market and enable more scientifically literate graduates to benefit the wider community.

Conflicts of interest

There are no conflicts to declare.

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This element of the study established a clear understanding of the extent to which science students at Monash University and the University of Warwick recognised and valued the development of transferable skills during their degree. The key findings were:

On average, students recognised the development of three (Monash) or four (Warwick) skills during their degree from amongst teamwork, communication, thinking and problem solving, laboratory and time management skills. Some students also recognised the development of organisational skills and a few recognised independent learning or study skills.

Students on average named three skills as being valued by employers from amongst teamwork, communication, thinking and problem-solving skills, time management and organisational skills.

The same core skills were recognised and valued by students across all three year levels of the degree and by both genders.

The skills desired by students for further development appeared to include those that they believed they needed to satisfy employers, as well as those that they believed they needed to succeed in their degree. These included communication, laboratory/practical skills, thinking and problem solving and time management skills, as well as skills that would help them prepare for the employment application process and a successful transition to the workforce (such as job application and interview skills, workplace related skills, career and business knowledge and work experience).

When compared with the views of employers and graduates as published in the literature, a reasonable proportion of students recognised that they will need teamwork, communication, thinking and problem solving, time management and organisational skills in employment and that they are developing these skills in their degree. However, students' perceptions were very narrow. They did not recognise that employers are seeking a much greater breadth of skills from graduates including numeracy, data analysis, independent learning, commercial/business awareness, interpersonal, research and computer/IT skills, as well as initiative and flexibility/adaptability, and students did not identify these skills as developed during their degree.

The inclusion of transferable skills in unit aims, learning outcomes or graduate attributes appeared to be insufficient to raise students' awareness of the breadth of skills they were developing through the curriculum.

These findings established a clear need for intervention in the curriculum to help students broaden their recognition of in-curriculum skill development and to increase their understanding of the skills that are required in the workplace. Chapters 4 to 6 will present the results of several interventions that aimed to raise students' awareness of transferable skill development experiences in the curriculum and of the importance of these skills and to help students to increase their ability to articulate these skills in preparation for the employment process.

4 Evaluating the impact of reflecting on curriculum-embedded skill development: the experience of science undergraduates

The first intervention considered for improving students' recognition and articulation of in-curriculum skill development was reflection. The research question addressed was whether reflection helps science students better recognise skills developed through the curriculum, enhances their ability to articulate their skills or benefits them in other ways.

Science undergraduates at Monash University were invited to participate in a semester-long program to identify and reflect each week on an in-curriculum employability skill development experience. The program commenced with a workshop that outlined the importance of employability skills, introduced reflection and demonstrated the online portal for writing skills reflections using a STAR framework. During the program, students were supported by weekly email prompts and several lunchtime discussions. Sixty students finished the program, each completing a pre- and post-program questionnaire and participating in recorded focus group discussions or interviews. Some students shared their written reflections for research purposes.

The questionnaire responses, focus group transcripts and reflections were analysed and the results were published as a peer-reviewed paper in the journal *Higher Education Research and Development*. The paper compared pre- and post-program student self-ratings of a range of skills, their confidence in navigating the employment process and their views on course quality, motivation and the value of the skills developed at university. The paper also explored the ways in which students benefited from skills recording and reflection, the challenges students experienced during the reflection process and how they can best be supported when engaging in reflection. The paper is presented in the following pages.

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Evaluating the impact of reflecting on curriculum-embedded skill development: the experience of science undergraduates

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ABSTRACT

Meaningful reflection on their learning and skill development is often lacking in the experience of undergraduates. Many students do not recognise the curriculum-embedded development of transferable skills and lack the ability to articulate such skills. This mixed-methods study sought to investigate whether engaging students in reflection would increase their ability to recognise and articulate their skill development. Sixty science undergraduates from Monash University completed a voluntary semester-long program recording and reflecting on course-related skill development, supported by email prompts and group discussions. The impact of students' involvement was evaluated through pre- and post-participation surveys, reflections and group discussions. Most students were challenged by the unfamiliarity of thinking beyond knowledge attainment in order to identify and reflect on skill-related experiences. However, they recognised a range of benefits from doing so, including an improved ability to recognise their skill development, strengths and weaknesses and to articulate their skills in readiness for seeking employment. They also valued previously unappreciated learning tasks and gained motivation to improve skill deficits and seek out opportunities to improve their employability. Based on this study, recommendations are made regarding best practice for implementing skills reflection in the curriculum.

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Evaluating the impact of reflecting on curriculum-embedded skill development: the experience of science undergraduates

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Meaningful reflection on their learning and skill development is often lacking in the experience of undergraduates. Many students do not recognise the curriculum-embedded development of transferable skills and lack the ability to articulate such skills. This mixed methods study sought to investigate whether engaging students in reflection would increase their ability to recognise and articulate their skill development. Sixty science undergraduates from Monash University completed a voluntary semester-long program recording and reflecting on course-related skill development, supported by email prompts and group discussions. The impact of students' involvement was evaluated through pre- and post-participation surveys, reflections and group discussions. Most students were challenged by the unfamiliarity of thinking beyond knowledge attainment in order to identify and reflect on skill-related experiences. However, they recognised a range of benefits from doing so, including an improved ability to recognise their skill development, strengths and weaknesses and to articulate their skills in readiness for seeking employment. They also valued previously unappreciated learning tasks and gained motivation to improve skill deficits and seek out opportunities to improve their employability. Based on this study, recommendations are made regarding best practice for implementing skills reflection in the curriculum.

Keywords: reflection, transferable skills, articulation, curriculum, employability

Introduction

The employability of graduates is an increasing focus for higher education institutions in the face of employer and graduate needs, government requirements, a highly competitive job market, rapid advances in technology and globalisation (Gunn et al., 2010; Jackson & Wilton, 2017; Oliver & Jorre de St Jorre, 2018; Saito & Pham, 2018). To obtain employment, succeed in the workforce and make a contribution to society, graduates are increasingly reliant on their ability to develop and apply a wide range of transferable skills (Bridgstock, 2009; Lowden et al., 2011; The Australian Industry Group, 2016; The Foundation for Young Australians, 2017; World Economic Forum, 2016). Such skills include critical thinking, creativity, innovation, independent learning, problem-solving, initiative, teamwork, leadership, communication, technology/digital literacy, numeracy, commercial/business awareness, interpersonal and career management skills.

In response to this need, universities are providing opportunities within the

curriculum for students to develop a range of skills. However, research suggests that undergraduates are primarily focused on knowledge and discipline-specific skill development and have very limited recognition of transferable skill development embedded in learning activities and assessments (Hill, Overton, Thompson, Kitson, & Coppo, 2019; Kinash, McGillivray, & Crane, 2018; Tomlinson, 2008). In order to realise the full benefits of their education, students must recognise that they have developed life and employment-relevant transferable skills and be able to articulate them (Harvey, 2005). Models of graduate employability development propose that reflection on learning and skill development is essential for students to develop the ability to recognise and articulate skills. (Dacre Pool & Sewell, 2007; Harvey, 2005). This is particularly important for graduates of generalist degrees such as science, as a significant proportion will be employed in jobs outside their degree major (Norton, 2016). Such graduates will be reliant on their transferable skills to obtain employment and succeed at work.

Dacre, Pool and Sewell (2007) postulate that without reflection and evaluation of their learning, students are unlikely to recognise that they have improved their employability and what they must do to further enhance and apply it. Kinash et al. (2018) highlight a disconnect between university assessment and employability amongst students and graduates. They have called upon educators to make more explicit links to employability and to encourage students to reflect on employment-relevant skills developed during assessment tasks.

Reflection has long been required of undergraduate students in health sciences and education (Gordon, 2003; Koole et al., 2012; LaBoskey, 1993; Yost, 2006), to maximise learning and identify opportunities to improve performance and outcomes. Bridgstock (2009) emphasises that personal reflective processes underpin the career management skills graduates will need to participate in lifelong satisfying employment that utilises their capabilities to contribute to society.

Despite these benefits, reflection is uncommon in STEM curricula, and there is a lack of research on the impact of engaging students in reflection focused on transferable skill development. Preliminary findings from engineering student involvement in reflection on their skill strengths, weaknesses and improvement goals emphasised the value of reflection over skill audits (Kaider & Shi, 2011). Kensington-Miller et al. (2018) discuss a framework to help undergraduates recognise, articulate and evidence attributes or skills that are often developed or required within a university degree and profession, but are not explicitly discussed or assessed. We hypothesised that engaging students in reflection on skill development experiences within their curriculum could help them to articulate skills of which they are currently unaware. The research questions we specifically sought to address were:

1. Would reflecting on skill-related degree experiences help science students better recognise skills developed through the curriculum, enhance their ability to articulate their skills and/or benefit them in other ways?

2. How can we best engage and support science students in reflecting on curriculum-embedded skill development?

Methodology

The methodology involves two components: Description of the educational intervention undertaken and the research methodology used to explore the research questions.

The intervention

Monash University science students were invited to participate in a voluntary semester long program to identify and reflect on experiences from their degree units that involved using or developing transferable skills. Lunch was provided during group sessions and those who completed the program received a certificate and gift voucher. A summary of the program, called "Skills to Work", is shown in Figure 1.

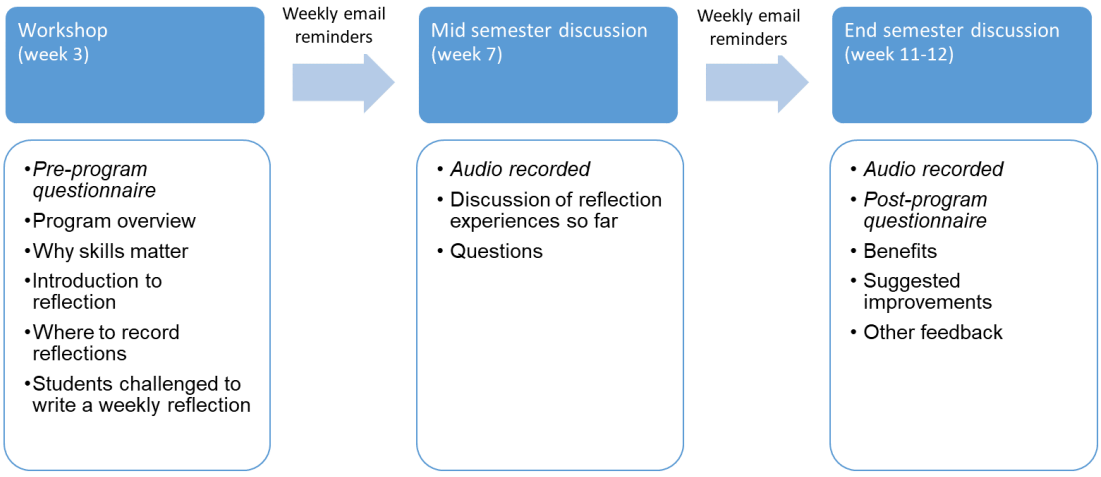

Figure 1. Skills reflection program

The program was designed using features identified in the literature for successful reflective use of portfolios in undergraduate education (Driessen et al., 2005) *i.e.,* structure and guidelines (provided during the workshop, mid-semester discussions and on the reflection platform), sufficient new and relevant experiences to reflect on (students could use experiences from throughout their degree) and mentor availability for coaching (the lead researcher).

Each student attended one workshop, mid-semester and end of semester discussion. Multiple sessions were facilitated with a maximum of twenty students attending each workshop and ten each discussion.

Students recorded their reflections in the Monash University "Student Futures" online platform. This platform offers students a list of nine employability skills and a "STAR" (Situation, Task, Action, Result) structure for writing their reflections, a

technique recommended by many universities and professional recruiters (O'Leary, 2013).

Research methodology

A mixed methods research approach was chosen to realise the benefits of both quantitative and qualitative methods and gain more insight into a complex experience (Creswell, 2009). Quantitative (survey-based) research obtains numerical results that can be easily used to compare 'groups' and evaluate differences, in this case, statistical comparison of the participants' views before and after the intervention (Choy, 2014). Qualitative research is 'broad and open-ended' (Choy, 2014) and enables the diversity of participants' experiences to be explored, as well as the value and meaning ascribed to them. This is important for determining the impact of the intervention and how best to support students when reflecting.

Quantitative data was collected via pre- and post-intervention paper-based surveys, which included the following elements to understand whether participation in skills reflection impacted students' opinions of their skills, degree, career preparation and employability:

- Self-rating of 22 skills identified from the literature as important in employment (The Australian Industry Group, 2016; World Economic Forum, 2016) (Response scale: 1 Non-existent, 2 Very limited, 3 Limited, 4 Moderate, 5 Good, 6 Very good, 7 Excellent)
- Interest in further education opportunities (Honours, Masters, PhD, none)
- Career directions under consideration (7 options and 'Not sure')
- Best stage of university to start actively preparing for a job/career (7 options, by semester)
- Extent of agreement with eleven statements about course/degree satisfaction, quality, motivation, skills and employment-related confidence (Response options: Strongly disagree, Disagree to some extent, Neither agree or disagree, Agree to some extent, Strongly disagree)
- Post-program only: Extent of attainment of eleven potential benefits of participating in skills reflection (Response options: None, A little, Some, A lot).

Qualitative data was collected through focus groups and interviews and written reflections. Seven focus group discussions were recorded at mid-semester and end of semester and two students who were unable to attend a scheduled group discussion completed an interview. The questions addressed were:

- How easy was it to identify skills you're developing through your course and reflect on them?
- What was challenging about this process?

- What helped you?
- What skills did you identify and in what situations?
- Did you feel there were any benefits from participating in skills reflection?
- Were there drawbacks?
- Do you have any suggestions for improving the program?

Students were invited to share their completed reflections so that the skills reflected on could be identified and compared with survey and discussion data.

The research was approved by the Monash University Human Research Ethics Committee (MUHREC), project 2017-0936-8426.

Student recruitment and participants

Participants were invited using flyers placed in informal spaces and lecture theatres and in person in second year core chemistry, biology, physics and earth sciences classes. Second year students were any deliberately targeted, since first year students in their first semester were likely to be focused on adjusting to university and third year students were often already engaged with job searching. Second year students potentially had time and further opportunity during their degree to act on any learning from the program.

Whilst participants included students from a variety of disciplines, course outcomes and skills for undergraduate Monash science degrees are consistent. *i.e.,* knowledge and technical skills, personal and social responsibility, understanding the importance of science and the ability to apply scientific knowledge to analyse and solve problems, collect and analyse data, communicate to a variety of audiences and learn and work both independently and collaboratively (Monash University, 2018).

Data analysis

Questions repeated on the pre- and post-program questionnaires were paired by student number and analysed by the Wilcoxon signed rank test using SPSS software, to test for statistically significant differences in student responses. Since 47 questions were evaluated, the standard 0.05 significance level was reduced to 0.011 using the False Discovery Rate Method (Benjamini & Yekutieli, 2001; Narum, 2006). This avoided a significantly increased chance of 'false positive' conclusions (type I error), whilst maintaining sufficient statistical power.

Focus group and interview recordings were transcribed verbatim and imported into NVivo 11 qualitative analysis software. Thematic analysis was carried out as per Creswell (2009). Three focus group transcripts were reviewed in detail and an initial set of themes was created, that were then given codes. These were then used to code two more focus group transcripts. Once thematic saturation was attained, two other researchers coded one of the focus group transcripts using the list of developed themes. The cross-coding comparison showed good agreement (78% and 84%) and the

remainder of the transcripts were coded accordingly. Interview transcripts were similarly analysed, with thematic analysis identifying the same themes as focus groups and hence the data from both sources is combined when reporting results.

Each reflection specified which skill students had written about and these were manually summarised. The median number of reflections per student, the average number of reflections per student per particular skill and the percentage of all reflections on a particular skill were calculated.

Findings

Sixty participants completed the reflection program. Demographics were typical of the Monash science degree cohort in terms of gender (53% male/45% female), student type (93% domestic) and degree type (57% science, 15% science/engineering, 12% science/arts and 15% other science double degree) and their science majors (biology, chemistry, physics, geoscience, maths, biochemistry, environmental). 75% were second year students, in accordance with the recruitment strategy.

Survey data

Student responses to statements about the impact of participating in skills reflection (Figure 2) can be summarised into three categories: 87-90% students agreed it helped them identify skills strengths and weaknesses, 63-83% students agreed it helped them prepare for the job application process, particularly in terms of developing examples they could use in job applications and interviews and 50-70% students agreed it helped improve their attitude to their course in terms of motivation, satisfaction and especially the value gained from it.

In terms of pre- vs post-intervention changes (Table 1), at the beginning of semester, only a third of students had any confidence in their interview and job application skills and only just over half thought the skills developed at university matched what employers were seeking. By the end of the program, a statistically significant number of students had gained confidence in these areas.

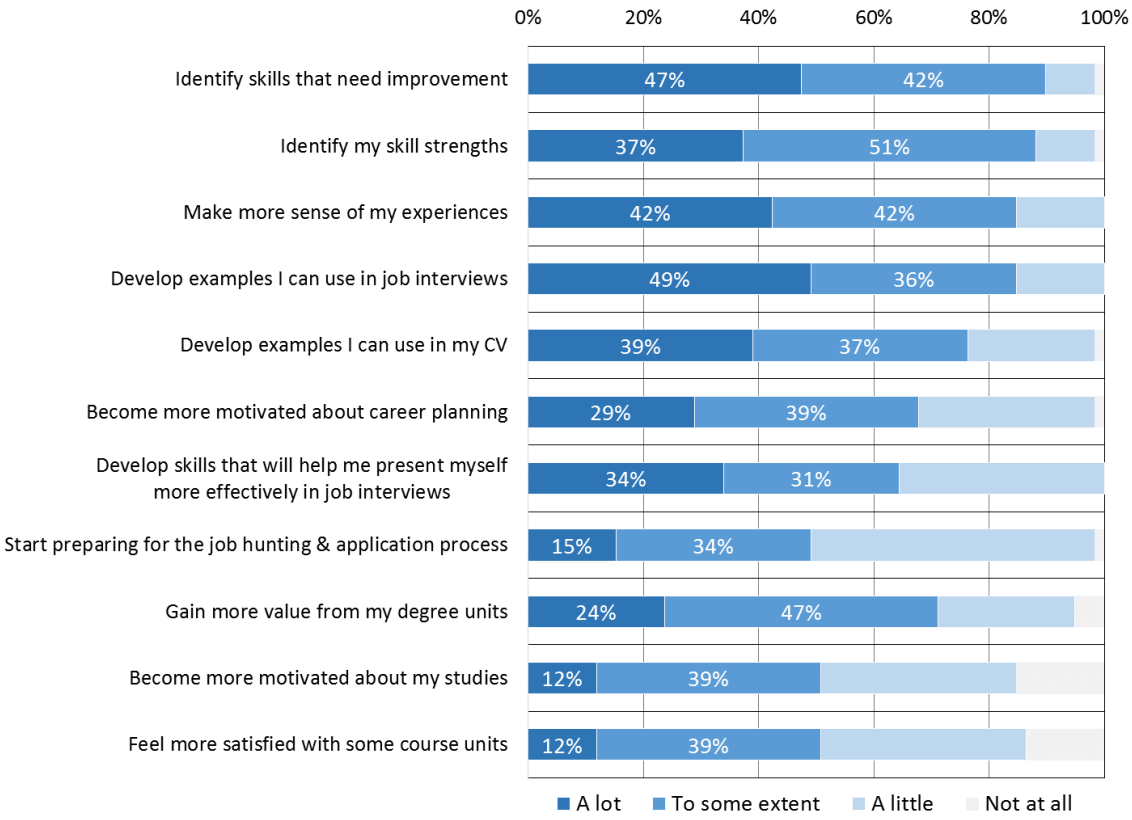

Figure 2. "To what extent has participation in skills recording and reflection helped you do the following?" (post-intervention survey)

Table 1. Student responses to statements about their degree and job preparation, pre- and post-intervention

Statement:	Stage of semester	% students agree	neutral	disagree	change over semester* Significance	Effect size
It is important to start preparing now for a job/career	start	100%			0.371	
	end	100%				
I will need to further develop some skills in order to be ready for the workplace	start	100%			0.225	
	end	98%	2%			
I will need to further develop some skills in order to be successful at gaining a graduate job	start	98%	2%		0.159	
	end	95%	5%			
I am satisfied with the course/degree I'm doing	start	95%	5%		0.819	
	end	95%	3%	2%		
I am motivated to complete my degree	start	95%	5%		0.074	
	end	93%	5%	2%		
The overall quality of my course/degree is very good	start	93%	5%	2%	0.862	
	end	95%		5%		
The skills I am developing at university are useful	start	82%	18%		0.117	
	end	90%	8%	2%		
The skills I am developing at university are what employers are looking for	start	55%	41%	4%	0.002	0.29
	end	80%	15%	5%		
I am confident in my ability to prepare high quality applications for graduate jobs	start	33%	25%	42%	0.007	0.25
	end	50%	20%	30%		
I feel confident in my ability to interview well for a graduate job	start	33%	29%	38%	0.023	
	end	38%	33%	28%		
I am confident of success in job interviews	start	28%	31%	41%	0.001	0.31
	end	42%	30%	28%		

*Shading denotes a statistically significant change

In terms of skill self-evaluation (Table 2), the skills that showed an increase in average self-rating at the end of the semester were communication (report writing, verbal and presentations), thinking and problem solving, research skills (experiments and information), leadership, computer/IT and quantitative/data analysis. These skills align well with many of the Monash science degree intended learning outcomes.

Survey responses showed no significant change in career directions or postgraduate education considered by students. Likewise, student opinions on when to start preparing for a job/career did not change, with two thirds of students nominating first year or first semester second year and 87% believing they should start preparing before their final university year.

Table 2. Student self-rating of skills at the start and end of the reflection program

Skill:	Average skill self-rating (1 to 7 scale)		Analysis of change over semester	
	Start semester	End semester	Significance	Effect size
Teamwork	5.36	5.62	0.039	
Initiative	5.27	5.35	0.694	
Independent learning	5.00	5.30	0.036	
Analytical/critical thinking	4.88	5.28	0.010	0.24
Ethical awareness/behaviour	5.07	5.27	0.151	
Problem-solving	4.88	5.22	0.008	0.25
Verbal communication	4.80	5.22	0.001	0.31
Laboratory/practical	5.03	5.20	0.164	
Adaptability/flexibility	5.12	5.18	0.542	
Written communication	4.92	5.18	0.017	
Report writing	4.66	5.17	<0.001	0.37
Research skills –information	4.46	5.10	<0.001	0.40
Leadership	4.76	5.08	0.004	0.26
Planning, organisation, time management	5.00	5.05	0.675	
Professionalism	4.97	5.03	0.765	
Presentation	4.51	5.03	<0.001	0.34
Computer/technology/IT	4.68	5.03	0.002	0.29
Intercultural competence	4.58	4.90	0.053	
Quantitative/maths/data analysis	4.49	4.88	0.002	0.29
Creativity/innovation	4.56	4.78	0.063	
Research skills -planning & designing experiments	4.08	4.52	0.002	0.29
Industry/business awareness	3.39	3.90	0.003	0.27

Shading denotes a statistically significant change over the semester

Skills reflections

Of the 60 program participants, 35 shared a total of 235 reflections with a median of six reflections each (Figure 3). Every student completed at least one reflection on teamwork and planning/organisation with most students also reflecting on communication, problem solving and use of tools and technology. Few students reflected on professionalism, creativity, initiative and intercultural competence.

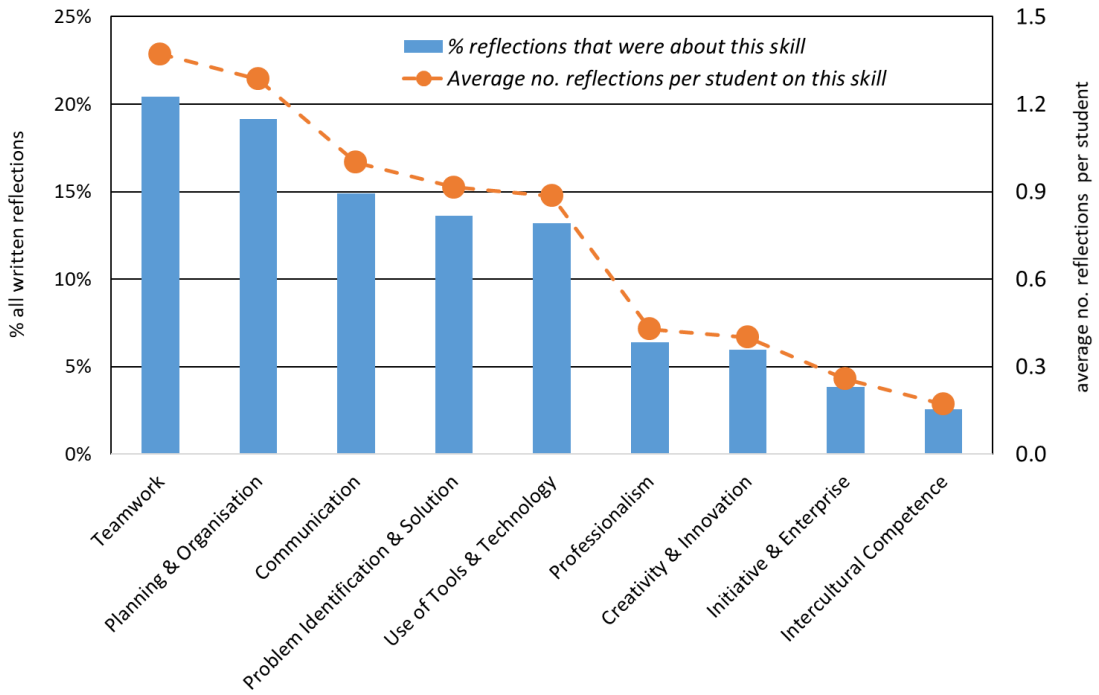

Figure 3. Skills reflected on by students

Focus group and interview data

Thematic analysis of mid- and end of semester transcripts identified five major themes and associated sub-themes related to student experiences of identifying and reflecting on curriculum-related skill development (Table 3). The prevalent skills and skill-development situations identified by students in the transcripts are presented in Table 4.

Students identified a lack of time and/or motivation as the most common barrier to writing skills reflection (Table 3). Students were very conscious this task wasn't assessed and hence found it hard to become motivated about it or prioritise it. This became a significant barrier in the second half of the semester, when assessment deadlines were prevalent. Some students also tended to procrastinate because getting a job was 'a few years away'. Hence, many requested credit-bearing skills reflection be made compulsory in the curriculum.

Some students were unaccustomed to identifying about their feelings and felt uncomfortable or ineffective at articulating them.

> I found it hard to write like what I was trying to get across …Like I could understand it in my head, but writing it down was difficult.

Another barrier was difficulty in identifying skills developed. Many students recognised only teamwork and communication skills.

> Every time I thought of a skill that I improved on, I thought, oh, this is communication or this is clearly teamwork. But the other skills are more difficult to identify. Like I couldn't think of any situations where I developed much on those other skills.

Table 3. Major themes and sub-themes from focus groups and interviews

Theme	Sub-themes	Examples
Barriers to writing skills reflections	• Lack of time and/or motivation • Difficulty in articulating skills and experiences • Difficulty in identifying a situation in which skill development had occurred • Difficulty in identifying which skill was developed	"I think the hardest part is … finding where you've developed that skill." "The writing part wasn't the hard part for me, it was trying to come up with a skill that you've used, instead of just topics that you've learnt."
Approaches to identifying skills and experiences	• Review recently completed major tasks/assessments • List everything completed in the past week • Identify what went well • Identify uncommon/new experiences • Review skills and situation prompts from reflection platform • Try to find an experience for each skill on reflection platform	"When I sit down for the reflection I think 'what's something that went well this week?"
Program elements that assisted students with skills reflection	• A list of skills to reflect on • Examples of situations which demonstrate each skill • A structure for writing reflections, with prompt questions • Reminders to write reflections • A summary of number of reflections completed per skill • Opportunities to discuss skills and experiences	"I find that the [STAR] prompt questions .. really help. ... It helps you structure it a lot more and it makes it a lot quicker to answer." "The [skill] prompts did help … they focused on the actual issue, on the actual skill and gave me different things to write about"
Improvements requested to skills reflection platform	• Reflection examples relevant to university students • Improved explanations and examples of some skills • More flexibility in the structure used to record reflections • Re-phrasing some skill prompts to allow for failure and subsequent learning or progress	"It would be good if you could choose .. multiple skills and then mention the scenario once and then talk about how you developed each individual skill, at the end."
Impact of engaging in skills reflection	• Preparation for the recruitment process (skill articulation and evidence) • New/improved recognition of skill development, strengths and weaknesses • Recognition of wider gains from course-related tasks • Actively thinking about skills during tasks and working on them • Identification of skills and employability gaps and taking action to bridge them • Gained/improved reflective skills • Development of critical thinking and communication skills • Negative impacts	"It directly helped me in my interview that I sat two weeks ago" "Becoming aware of skills that you may not have noticed that you had before and having an example of where you got them." "It's helped me to be more engaged in activities; like be more ambitious"

Table 4. Skills identified during focus groups/interviews as developed within the curriculum and in what situations

		% mentions
Skills identified as developed	Teamwork	26%
	Communication	20%
	Use of tools and technology	13%
	Organisation/time management	12%
	Problem-solving	7%
	Professionalism	6%
	Data analysis	4%
	Initiative	4%
	Leadership	3%
Course contexts perceived to facilitate skill development	Group work (assignments, projects, presentations)	29%
	Laboratory/practical work	29%
	Tutorials/workshops (discussion, problem-solving activities)	10%
	Presentations	8%
	Data analysis/coding/statistics tasks	8%
	Interactions with staff	6%
	Field trips	4%

There was also a perception that science offered little scope for creativity ("set methods") and that it was difficult to identify examples of intercultural competence.

Many students also struggled to identify skill-building situations. This was due to an overriding focus on task completion, a lack of awareness that a skill was being developed, difficulty isolating a specific instance when skill development occurred, or because their learning activities seemed mundane or not 'big' enough to record.

In order to identify skill development experiences, students often reviewed what they'd done at university in the past week, particularly completed assessments, 'what went well' or anything different; "things [that] aren't just my normal things that I do". Many students believed that new experiences are most likely to develop skills and that the repetitive nature of university tasks and assessments led to a lack of situations to draw from.

> You feel like you're doing the same skills over and over. Because it's always going to be the same; your unit's going to be the same. So unless something changes …if you do a different activity I guess you learn new stuff. That doesn't really happen too much.

Some students recognised they were developing skills incrementally, but didn't know how to express that coherently or share it with a potential employer. Eventually some students began recognising they could reflect on common course-related activities.

> A recent [reflection] I did was a hazards assessment,…which I have to do each lab session.…I thought, well I do this every week, so I obviously have a lot of experience in it. What am I actually getting out of doing this very monotonous task now? It seems very routine now, but obviously at the start it didn't, so I must've learned something.

Several aspects of the skills reflection program helped students identify and articulate their experiences (Table 3). Of these, involvement in discussions made a notable difference by sparking new ideas and helping students recognise they had developed a wider range of skills. Skills such as initiative, independent learning, flexibility/adaptability, creativity and problem-solving were often not identified by individual students, but were later recognised after discussion with the group. The online reflection platform skills list and examples of situations which can demonstrate them, also helped students find instances to reflect on.

With practice and support, many students found it became easier to identify skills and skill-building situations, and to reflect.

> At the start, you would struggle to think of things to reflect on. Then as the semester progressed, you were more aware of what you could reflect on, so after the lab or a presentation or any other situation you'd be like, 'oh I can reflect on that', whereas before you wouldn't really have been that conscious.

Those students who engaged in skills reflection identified a range of benefits (Table 3). Preparation for the recruitment process was mentioned frequently, as students felt they had developed their ability to recall, articulate and provide evidence of their skills, helping them more confidently build their resume and answer interview questions.

> It's valuable to write the skills down, and reflect on them, because then you can talk about them in the interview and you have like this whole range.

Students appreciated that they could export their reflections to use in job preparation and that the platform allowed reflection on both curricular and extra-curricular experiences.

Many students also benefited by recognising wider gains from course-related tasks, including 'mundane' experiences, with a resultant increase in motivation and a feeling of greater productivity.

> It surprised me to find myself realising why we were actually made to do some activities in classes that at the time I thought pointless. Upon reflecting I found I did actually gain some important skills from class activities.

Skills reflection helped students recognise that they could take action whilst carrying out a task, to further develop the relevant skill. They also identified gaps in their skills and employability and acted to bridge these, *e.g.* by attending university careers nights or seeking out new work or volunteering activities. Some students summarised the benefits of skills reflection as increased awareness; of their skills, learning, employment preparation and future.

Few negative impacts of participating in skills reflection were identified. Two students felt guilty for not completing more reflections or doing enough to develop their skills. Several students became self-critical and focused on mistakes. Four students found it a negative experience overall; "Felt like a chore, hated doing it". However, they continued with

the program in the subsequent semester, with three later reporting benefits.

Amongst the improvements requested to the skill reflection platform was more flexibility in the structure used to write reflections. Specifically, students wanted to combine the 'Situation' and 'Task' elements of STAR (to reduce repetition); specify their own situation; reflect on multiple skills under a single situation/task and reflect on additional skills (beyond the nine provided in the platform, shown in Figure 3).

Participant observations on skill building situations have the potential to inform teaching practice (Table 4). Many observed that skill development is most likely to occur when interacting with others: "Mainly when you're interacting with other people .. you develop.. most of the skills". Some students taking majors that offered few group projects (*e.g.* maths, physics), felt disadvantaged by this. Students also noted that facing problems helps you develop skills; "I had to come up with ways to resolve these issues and that led to skills" and that if teaching staff intervene too much, students will be prevented from developing skills associated with working through challenges. Interactions with teaching associates/demonstrators or academics, such as asking questions, seeking feedback or resolving conflicts, also led to skill development.

Individual assignments and lectures were rarely linked to skill development. Lectures were only seen to foster skills when they incorporated problems or quizzes. Students also observed that closed tasks and prescribed methods restrict skill development:

> A lot of labs, the method's pretty set and you know if you're careful with your work you're not going to have any mistakes. And so at the end of it I don't feel like I've used as many skills.

Research projects were only mentioned by two participants, probably because most were early in their second year, and hadn't yet been involved in them.

The three benefits of participating in skills reflection most prevalently mentioned in discussions and interviews were also highlighted by the survey data:

'Preparation for the recruitment process' was supported by 77-85% students from survey responses (Figure 2) agreeing that skills reflection helped them develop examples they could use in interviews and CVs. There was also a significant improvement in confidence regarding interviews and applications in the post-program survey (Table 1).

'Recognising previously unnoticed skill development, strengths and weaknesses' was confirmed in survey responses by 87-90% students (Figure 2).

'Recognising wider gains from university and course-related tasks' was also confirmed in survey responses (Figure 2 and Table 1), with significantly more students convinced post-program that the skills they're developing at university are what employers are seeking.

In terms of skills identified by students as developed, those most commonly mentioned in focus groups and interviews (Table 4; teamwork, communication, use of tools and technology and organisation/time management) were in good alignment with the skills students reflected on during the program (Figure 3). Likewise, those rarely discussed (Table

4) aligned with the skills very few students reflected on (professionalism, creativity, initiative and intercultural competence). Problem solving was an exception in that it was only mentioned at low frequency by students in discussions (7%), although 62% students that shared their reflections wrote about it. Examples of developing this skill were not 'top of mind' for students during discussions.

Uplift in skill self-ratings post-program (Table 2) also aligned with the most frequently mentioned skills during discussions, with the exception of organisation and time management. Many students articulated that reflection had exposed the latter to be a weakness, which may be why it showed no self-rating improvement.

It is interesting to note that whilst skill self-rating improvements at the end of the semester included analytical and critical thinking, data analysis, researching information, experimental design and industry awareness, these skills were rarely (if ever) explicitly identified by students during discussions or interviews. It is possible that without being prompted by a (survey or reflection) list, students don't readily recall that they have developed these skills and/or instances when they have used them.

Limitations

A limitation of this study is that since students self-selected to participate, they may not be representative of their cohort. In addition, the Student Futures platform listed only nine skills, which may have limited or influenced students' perception of the skills they were developing in their degree. Finally, since the research was carried out as an extra-curricular program, it cannot be assumed all findings will be replicated when skills reflection is implemented into the curriculum. The involvement of a facilitator/mentor may have increased the observed positive impacts.

Discussion, conclusions and recommendations

The outcomes of this study indicate that reflecting on skill-related degree experiences can positively impact science students in many important ways.

Most science students in this study did not initially have confidence in their ability to articulate their skills and undertake job applications or interviews. A significant number of students increased in confidence in these areas by reflecting on university experiences, highlighting the potential of skills reflection to help students prepare for the recruitment process. Through skills reflection, most students articulated new examples they could use in interviews and their CV.

Prior to reflection, many students didn't believe the skills developed at university were relevant to employers, and believed some curriculum tasks were 'a waste of time'. Participating in skills reflection helped many students recognise skill development as the purpose for some assessments, enhancing their motivation and satisfaction. This confirms a need to help students explicitly link their university activities to employability. Students in a Kinash et al. (2018) recent study likewise pointed out a 'missing link' between assessment and employability. Academics need to explicitly communicate the purposes of tasks to

students, especially the skills embedded within, and provide opportunities for reflection to reinforce learning-employability links. Communicating the importance of skills for employment is also key, as stated by Tymon (2013). When these benefits are recognised, students feel they gain greater value from their degree and that they can use their degree experiences when applying for jobs. As one student concluded of her reflection experience "It's helped me realize that the things we do in uni while they may seem useless ARE actually helping us develop skills that I can use in the future".

Our findings suggest that involvement in skills reflection can be a useful pathway to engaging students in career self-management behaviours at university, as called for by Bridgstock (2009) and Clarke (2018). Through reflection, some students were motivated to take action during classes to improve their skills and/or seek out new opportunities to fill skill gaps and prepare for their career, including internships, volunteering, leadership programmes, networking or collaborative opportunities. Skills reflection also led to changes in some students' self-perceived employability, which is linked to employment market success (Clarke, 2018).

However, even though students agreed in surveys and focus groups/interviews that reflection helped them better identify skills developed through the curriculum and their skill strengths and weaknesses, there were still skills they didn't readily identify through curriculum tasks, even when provided with a skills list for reflection. These included professionalism, initiative, creativity and intercultural competence, despite the fact that the latter two are long-standing Monash graduate attributes (Monash University, 2019). This suggests that either academics aren't successfully embedding these skills in the curriculum or aren't communicating them to students. Likewise, whilst comparison of pre- and post-program surveys indicated students believed they had improved in problem solving, critical and analytical thinking, data analysis and research skills, in line with Bachelor of Science expected learning outcomes (Monash University, 2018), students rarely articulated examples of these skills during discussions and interviews, without prompting. This reinforces the need to both explicitly sign-post skills students can develop during tasks and to widen the range and depth of skills incorporated. This study suggests the latter could be achieved in part by providing more open-ended tasks and research projects, a greater variety of learning activities and assessments and more opportunities for student interaction with each other and academics.

The outcomes of this study also suggest a number of ways to engage and support students in reflecting on curriculum-embedded skill development. Students should be provided with opportunities within the curriculum to reflect on skill development, linked to credit to signal value and enhance motivation (MacCallum & Casey, 2017; Palmer, 2004). Jorre de St Jorre and Oliver (2018) state "the most reliable way of developing students' ability to self-assess, evidence and articulate their capabilities would be to design assessment in which it is specifically required". Our research suggests that incorporating skills reflection as an assessed task in relevant units could serve this purpose. Tutors will have an important role in highlighting growth and successes to students who are inclined to focus on

weaknesses.

Students should also be provided with opportunities within the curriculum to discuss skill development with their peers and academic staff because, in so doing, students recognise a broader range of skills.

The majority of students in this study were interested in career-enhancement activities early in their degree and such tasks (including skills reflection) should be incorporated from at least the start of their second year in order to maximise the time students have to benefit from their experiences.

Engaging students in reflection on curriculum-embedded skill development should not be an isolated occurrence in one unit, as the research shows most students need multiple opportunities to learn to recognise and articulate their skills and where they have developed them. Students expressed a desire to reflect on their progress over time. Mirriahi, Joksimović, Gašević, and Dawson (2018) likewise called for reflection to be implemented at a program level to enable students to develop their meta-cognitive awareness and reflective abilities. It is also important to introduce reflective tasks early in a semester, when students have more time and cognitive load is lower.

Figure 4 summarises the research outcomes for how to best support students in reflecting on curriculum-embedded skills development, suggesting best practice for implementation in any subject or degree.

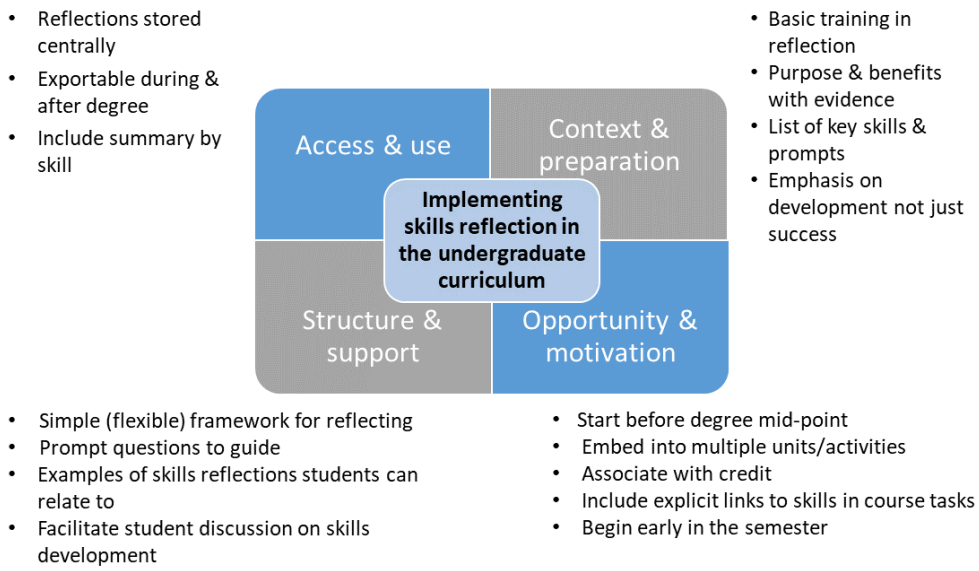

Figure 4. Recommendations for implementing skills reflection in the curriculum

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This element of the study established an understanding of the extent to which reflection assisted students to recognise curriculum-embedded skill development and to develop the ability to articulate their skills in preparation for employment. It also proposed detailed recommendations for how to best implement skills reflection in the curriculum. The key findings were:

Reflection significantly enhanced students' ability to articulate their skills, identify examples they could use in the recruitment process and increased their confidence in their ability to undertake job applications and interviews.

Prior to reflecting, many students did not recognise skill development as a purpose of curriculum tasks, confirming a need to for academics to explicitly link curriculum tasks to skills and employability, as identified in prior studies. Students' motivation and satisfaction were enhanced through recognising the skills that could be developed through completing degree tasks.

Reflection assisted students to recognise skills developed through the curriculum and skill strengths and weaknesses. However, there were some skills students still struggled to identify despite reflecting and prompting from a skills list, including professionalism, initiative, creativity and intercultural competence. Students either lacked the opportunity to develop these skills in the curriculum or they needed to be far more explicitly communicated by academics. Students also struggled to recall specific examples of developing problem solving, analytical and critical thinking, research and data analysis skills.

Students called for multiple opportunities within the curriculum to reflect on their skill development, linked to credit, to enhance motivation. Providing structure and support (such as a list of skills, prompt questions, examples of reflection and discussion opportunities) assisted students to develop their reflective abilities.

These findings confirmed that reflection helps students develop the ability to articulate their skills and can improve their recognition of some skills. However, reflection alone does not improve the recognition of all curriculum- related skill development and students will require clear sign-posting of some skills to further increase the breadth of in-curriculum skill recognition. Chapter 5 will present the results of a second intervention that aimed to expand students' skill recognition by making explicit links between transferable skill development opportunities and individual curriculum tasks.

5 The impact on undergraduates and teaching staff of displaying transferable skills badges

The second intervention considered for improving students' recognition of in-curriculum skill development was displaying transferable skills badges on curriculum tasks. The specific research questions addressed were whether displaying skills badges in the curriculum leads to enhanced student recognition of skill development opportunities and whether the badges have any other impacts on students and teaching staff.

Transferable skills badges were displayed on curriculum materials in six units at Monash University and three units at the University of Warwick. Mixed methods research was conducted amongst students who completed the units both before and after the badges were added, with 1952 students completing questionnaires and 103 participating in focus groups and interviews. Seventeen TAs participated in focus group discussions.

The questionnaires and focus group and interview transcripts were analysed and the results were published in a peer-reviewed paper in the journal *Active Learning in Higher Education*. The paper evaluated the change in students' recognition of in-curriculum skill development after experiencing the displayed badges, students' understanding of the purpose of the badges and the reactions to and benefits of the badges for both students and TAs. The paper also discussed how the implementation of the badges could be improved to maximise their effectiveness. The paper is included in the following pages.

Article

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'They help us realise what we're actually gaining': The impact on undergraduates and teaching staff of displaying transferable skills badges

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Abstract

Attaining transferable skills is increasingly important for undergraduates and, while such skill development may be embedded within the curriculum, it is often not well recognised by students. This mixed methods study explores the use of skills badges as icons displayed on curriculum materials in several disciplines at two universities. The badges are designed to draw students' attention to skill development opportunities; an approach that is easily scalable in any discipline. Results indicated that more than half of students found the badges helpful and their recognition of the development of some skills increased. Other benefits included understanding the wider

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purpose of learning tasks, increased motivation and satisfaction and identification of examples for use in the job application process. The badges prompted some staff to communicate with students about skills and to re-evaluate their teaching approach to maximise skill development opportunities. Communication between staff and students is key to ensuring students understand the purpose of the badges and how to use them.

Keywords
badges, curriculum, employability, skill recognition, transferable skills

Graduate employability and the curriculum

New graduates face many challenges including competitive and rapidly changing employment markets related to technological advancements, globalisation and disruption of business and employment models (The Foundation for Young Australians (FYA), 2017; World Economic Forum, 2016, 2018). Institutions are urged by employers and governments to help students develop their employability while still delivering disciplinary knowledge, and may be rated on students' employment outcomes (Bennett et al., 2015; Christie, 2017; Lowden et al., 2011; The Australian Industry Group, 2016). While not the only essential attribute (Clarke, 2018; Tomlinson, 2017), a key element of undergraduate education is the attainment of core, transferable, employability or enterprise skills. We use the term 'transferable skills' as it encompasses skills that may be applied across many contexts including education and employment and which can help navigate change and challenges (FYA, 2016). Such skills are critical for success in the workplace, as well as academic/research careers and employers require applicants to articulate them in job applications (Deloitte, 2019; QS Intelligence Unit and Institute of Student Employers, 2018). These skills include communication, problem-solving, critical thinking, organisation, creativity, digital/information and communications technology (ICT), numeracy/data analysis, independent learning, adaptability and resilience.

Universities are incorporating opportunities for students to build and demonstrate transferable skills within the curriculum (Taber, 2016). However, research suggests that students are often discipline and task-focused and do not recognise their breadth of curriculum-related skill development (Hill et al., 2019; Tomlinson, 2008). There is a strong relationship between students' self-perception of transferable skill competencies and their belief in their preparedness for work (García-Aracil et al., 2018), and educators have called for explicit links to be made between the academic curriculum and employability (Kinash et al., 2018; Lowden et al., 2011). Oliver and Jorre De St Jorre (2018) recommend that graduate attributes important to employability are communicated and explained repeatedly throughout the course. Matthews and Mercer-Mapstone (2018) emphasise providing multiple opportunities for practicing transferable skills in the curriculum in ways that make them visible to academics and students.

Skills badges have been discussed in literature as potential tools for engaging students, motivating and rewarding learning and evidencing progress and skill attainment to students and employers (Gibson et al., 2015; LaMagna, 2017). Typically, such badges (in digital format) are awarded to students after demonstrating proficiency in transferable or technical skills gained during an academic course but not explicitly graded (Bowen and Thomas, 2014; Devedžić et al., 2015; Seery et al., 2017) and/or during extra-curricular activities (Miller et al., 2017). Digital badges can be a more transparent and detailed credential than an academic transcript, as they contain embedded metadata and can be linked to assessment details and learner-specific evidence of competency (Casilli and Hickey, 2016).

While there are significant potential benefits of awarding digital badges, the associated assessment process requires educators to have access to 'a well-defined, open and expandable set of [transferable or technical] skill metrics' and opportunities to measure such skills (Devedžić et al., 2015). Ideally, skill metric definitions are agreed and available institution-wide to maintain consistent standards.

Decisions must be made on different badge levels, how to observe skill-related behaviours, using individual or group-based assessment, evidence for awarding badges and how skill development is scaffolded prior to assessment (Casilli and Hickey, 2016; Devedžić et al., 2015).

There is a need to investigate a simpler application of badges: as icons displayed on task and assessment resources to visually identify curriculum-embedded transferable skill development opportunities. This approach could make explicit links between academic curricula and employability and make the relevant skills visible to both students and teaching staff. This approach is a form of transparent curriculum design through which students may better understand the purpose of specific learning experiences, potentially leading to improved learning outcomes (Winkelmes, 2013). The research questions were as follows:

- Does embedding skills badges on curriculum materials lead to enhanced student recognition of skill development opportunities?
- What other impacts do the badges have on students and teaching staff?
- Which factors might increase the impact of the badges?

Methodology

Eleven transferable skills were identified from the literature (Deloitte Access Economics, 2014; Lowden et al., 2011; Sarkar et al., 2016; Saunders and Zuzel, 2010) and badges were designed for each (Figure 1).

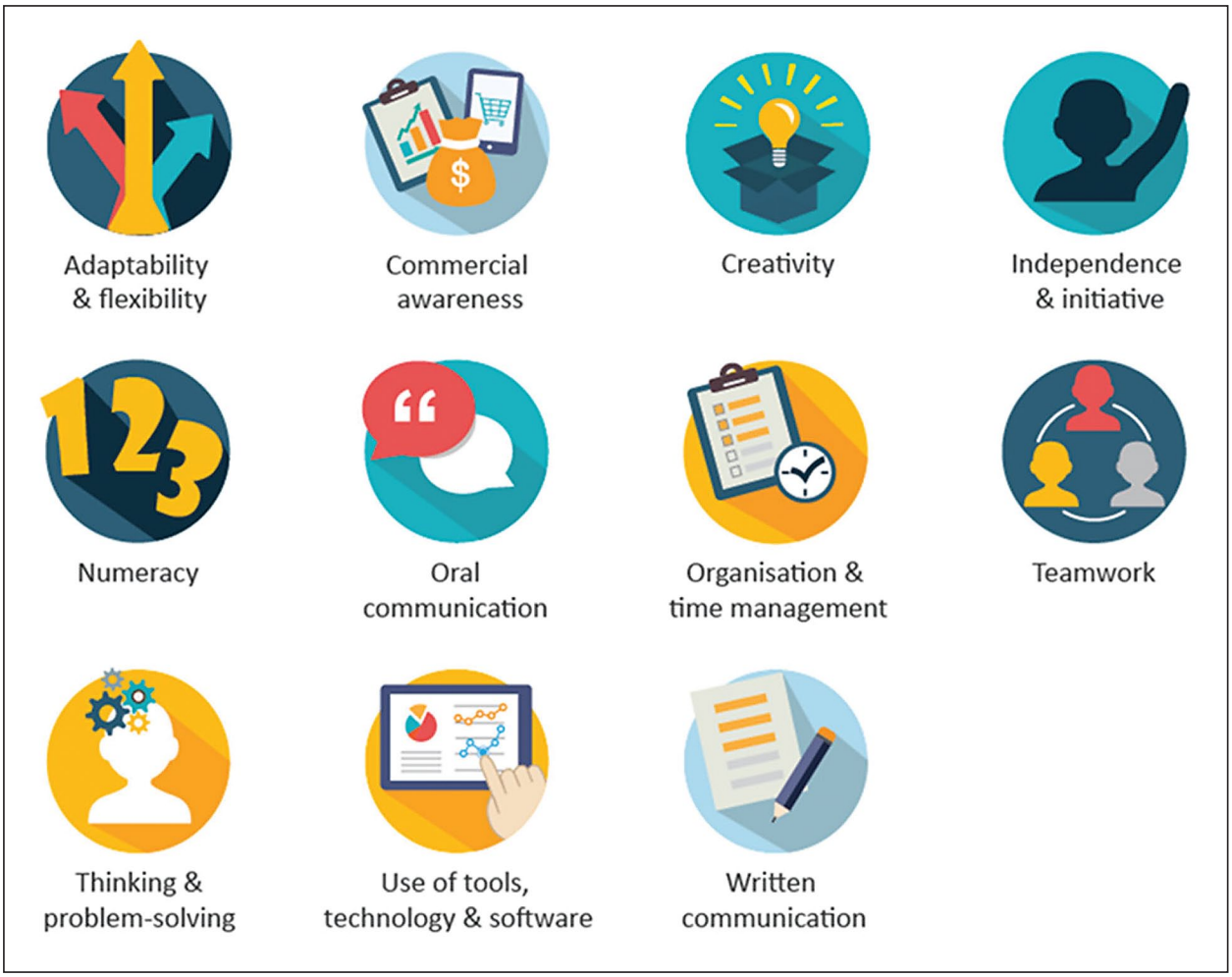

Figure 1. Skills badges.

These badges were applied to student-facing curriculum materials in six science units at Monash University in Australia and three modules at the University of Warwick in the United Kingdom (collectively referred to as 'units'). Table 1 summarises the units involved and where badges were displayed within each.

Table 1. Summary of units researched.

University	Unit/module		Year level	Location of badges[a]	No. surveys completed (% cohort)	
					Pre-badging	Post-badging
Monash	CHM2911	Inorganic and organic chemistry	2	Laboratory manual	146 (48)	139 (64)
	GEN2041	Foundations of genetics	2	Laboratory manual and VLE	153 (85)	165 (80)
	SCI2010	Scientific practice and communication	2	Workshop workbook, slides and VLE	306 (52)	282 (50)
	CHM2962	Food chemistry	2	Laboratory manual	NA	166 (80)
	BIO3070	Trends in ecology	3	Laboratory manual	NA	61 (67)
	SCI3930	Career skills for scientists	3	VLE and workshop slides	NA	204[b] (83)
Warwick	CH155	First year labs	1	Laboratory proformas and VLE	72 (45)	107 (74)
	CH222	Second year labs	2	Laboratory proformas and VLE	88 (49)	128 (82)
	CH2A5	Key skills	2	2 slides + 10 badges awarded through VLE	70 (39)	66 (42)

VLE: virtual learning environment.
[a]On the VLE, badges were shown under each laboratory/workshop title.
[b]Total from two cohorts.

Skills badges were selected by each unit coordinator (the academic responsible for curriculum and assessment). Typically, two or three relevant badges were displayed at the beginning of each workshop, laboratory activity or assessment task alongside the learning outcomes. Individual badges were also used at important points during the task where the skill would be required. If a student manual was provided, a summary page showed the skills badges, with a paragraph explaining their purpose and importance. The badges were displayed in colour in all units except GEN2041.

For one Warwick module, CH2A5, the coordinator modified the intervention by awarding digital versions of the badges to students on successful completion of each of five assignments, through the virtual learning environment (VLE; Moodle). In this module, badges were displayed to a very limited extent on curriculum materials. The other Warwick modules (CH155 and CH222) applied the main intervention of displaying badges.

Data collection

The mixed methods research methodology involved quantitative data collection via surveys and qualitative data collection via an open-ended question and student and staff focus groups and interviews.

A paper-based questionnaire asked students to what extent each unit provided an opportunity to develop 18 skills (‘none’, ‘a little’, ‘some’ or ‘a lot’). These 18 skills included the badged skills; however, the badge names (which grouped related skills together) were divided into their components on the questionnaire where relevant. For example, ‘thinking and problem-solving’ was divided into ‘analytical/critical thinking’ and ‘problem-solving’. These components were used to evaluate whether students recognised the individual skills. Several other skills not emphasised in the employability literature (literature research, experiment design, ethical awareness) were also added. This was to ensure the questionnaire was not biased by listing only the badged skills and to present most skills students were likely to develop. Students were asked how important they thought each skill was likely to be in helping them obtain a job and succeed at it after graduation, their career aspirations and demographic questions (gender, age, year level, domestic/international, degree and major).

This pre-badging questionnaire was administered at the end of the teaching period of six units in 2017, before badges were added to curriculum materials. The post-badging questionnaire was administered a year later (in 2018) with a new cohort of students, after the badges had been displayed for a full teaching period. The post-badging questionnaire included additional questions about how often students noticed the badges on course materials, their extent of agreement with statements about the badges’ impact (‘strongly disagree’, ‘disagree to some extent’, ‘neither agree or disagree’, ‘agree to some extent’ and ‘strongly agree’), and an open-ended question (‘Do you have any other comments about the skills badges?’). For a further three units (CHM2962, BIO3070 and SCI3930), only the post-badging questionnaire was administered, due to timing constraints.

The students from Monash University were studying a 3-year Bachelor of Science degree or a 4- to 5-year double degree incorporating a science major and another discipline (e.g. arts, commerce, engineering). University of Warwick participants were studying a 3-year Bachelor of Science in Chemistry or 4-year Master of Chemistry degree.

Students were invited to complete the questionnaires during, or at the end of, a workshop, laboratory class or lecture. University of Warwick and Monash CHM2911 students were offered refreshments. Students from all units except SCI3930 were invited to participate in focus groups, with refreshments provided. Eighteen student focus groups (involving 98 students) and five interviews (with students who could not attend the focus groups) were conducted (10 pre-badging and 13 post-badging). The questions were as follows:

> What skills did the unit offer the opportunity to develop and through which activities/tasks?;Did you notice you were developing these skills whilst you were doing the unit?; What impact, if any, does it have on you when you recognise you’re building skills in your course?; What skills will be important for you to gain employment and succeed at work after graduation?

Post-badging only (if unmentioned):

> Did you notice skills badges on unit materials?;What do you think their purpose was?; Were they helpful in any way?; Were there drawbacks to displaying the badges?; Did teaching staff talk about the skills/badges?; What improvements could be made to the badges or their implementation?

For all units except SCI3930 and CH2A5, Demonstrators or Teaching Associates (TAs) (part-time tutors of undergraduates, referred to hereafter as TAs) were invited to participate in focus groups or interviews at the conclusion of the teaching period when badges were displayed. A total of 17 of 62 chose to do so. They were asked which skills they thought the unit offered students the

opportunity to develop, their perceptions of the impact of the badges on students and themselves, and how the badges or their implementation could be improved. While both are employed to teach in laboratories or workshops, 'demonstrators' is the term commonly used at the University of Warwick and 'teaching associates' at Monash University. Both are responsible for introducing tasks, providing guidance and marking assessments. Academics also teach in tutorials, workshops and/or lecture settings. 'Teaching staff' refers collectively to the unit coordinator, TAs and academics involved in teaching a unit.

The research was approved by the Monash University Human Research Ethics Committee (MUHREC), project 2017-0936-13535.

Data analysis

Survey data was transcribed into Excel. The Mann-Whitney *U* test (SPSS software) was used to compare pre- and post-badging survey responses on the extent students believed each unit offered the opportunity to develop specific skills. Fisher's exact test (SPSS) was used to explore the relationship between how frequently students noticed the badges and their extent of agreement with statements about the badges. As 24 comparisons were made, the standard 0.05 significance level was reduced to 0.0132 to decrease the likelihood of a type 1 error ('false positive'), as per the False Discovery Rate Method (Benjamini and Yekutieli, 2001; Narum, 2006). Effect sizes were calculated as per Pallant (2016) and interpreted as per Lenhard and Lenhard (2016) and Kim (2017).

The 23 student ($n = 105$) and eight TA ($n = 17$) focus group and interview recordings were transcribed verbatim. These were imported into NVivo 12 qualitative analysis software and analysed thematically as per Creswell (2009). Initially, half of both the pre- and post-badging transcriptions from five units were studied in detail and an initial set of themes was developed, with sub-themes as relevant. These themes were then used to code further transcripts from the same units. When saturation was reached, that is, no new themes were identified, the theme list was reviewed and small or overlapping sub-themes combined. Two other researchers then independently coded two focus group transcripts using the themes provided. After discussion with the other coders, two intersecting themes were combined into one and the titles of several themes were refined, with the final cross-coding achieving 76% agreement. The final themes were then used to code the remaining transcripts. Responses from the survey open-ended question were imported into NVivo 12 and independently analysed for themes and coded. Cross-coding of responses from two units by two other researchers achieved good agreement (86%).

Results

Results indicate that an average of 92% of students noticed the badges and 75% noticed them more than 'occasionally' (Figure 2). An average of 58% students agreed that displaying skills badges was a positive addition to the unit (Figure 3), with only 6% disagreeing. Two thirds of students felt the badges helped them recognise skills they could gain from the unit and 54% agreed they prompted them to think about skills, not just the course content.

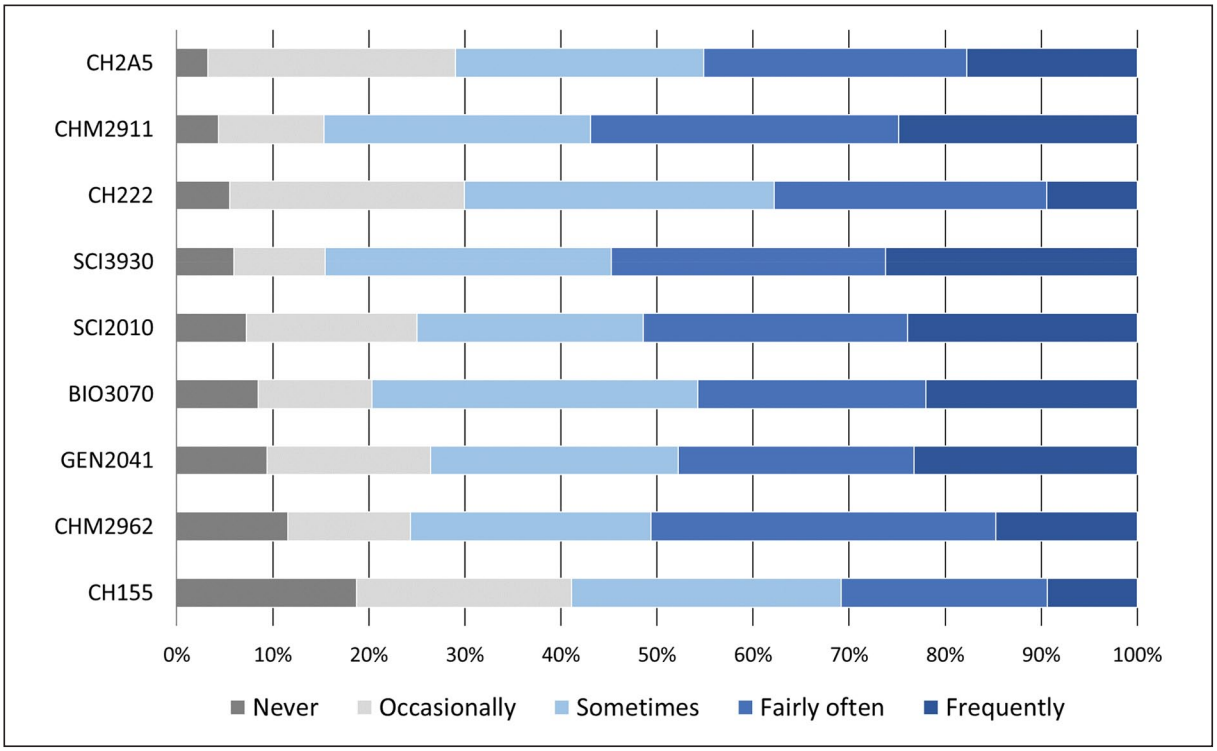

Figure 2. Percentage of students noticing the skills badges for each unit.

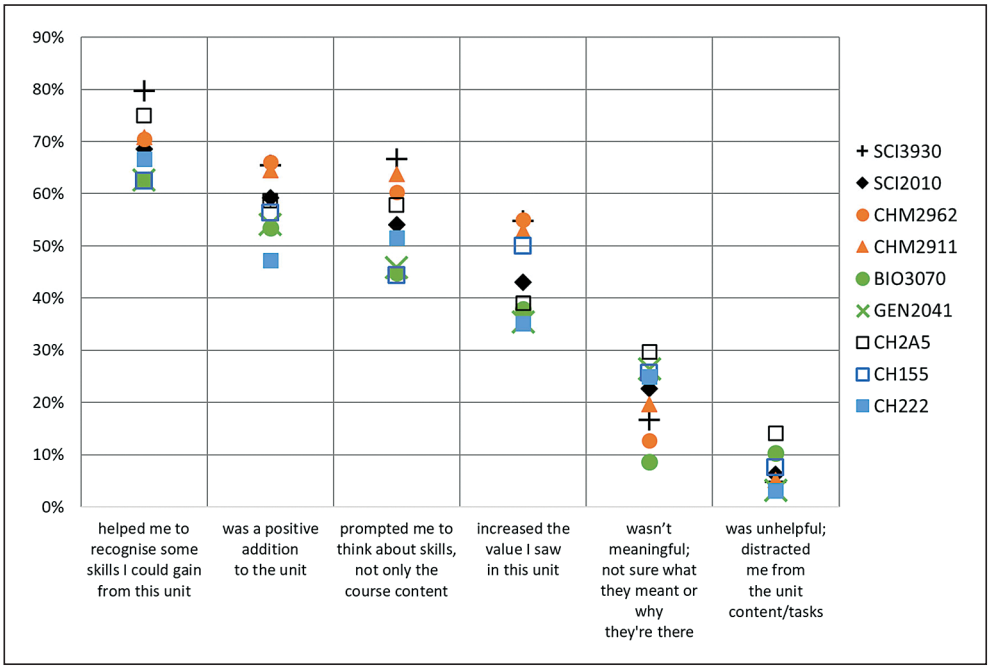

Figure 3. Percentage of students agreeing to some extent or strongly agreeing with statements about skills badges for each unit.

Results typically identified a statistically significant increase in the extent to which students believed each unit had offered the opportunity to develop several skills, at small- to medium-effect size (Tables 2 and 3). The skills where the uplift was observed were those where pre-badging recognition was moderate to low (Tables 2 and 3). The badges thus appeared to assist in recognition of development opportunities for skills that were less obvious to students initially.

Table 2. Changes in student recognition of skills, post-badging,Monash units.

Skill badge displayed *Skill researched*	CHM2911				GEN2041				SCI2010			
	Skill development rank[a]	No. badges	Sig. level	Effect size	Skill development rank[a]	No. badges	Sig. level	Effect size	Skill development rank[a]	No. badges	Sig. level	Effect size
Adaptability/flexibility	8		0.052		10		0.223		11		0.638	
Commercial awareness	12	2	0.002*	0.19	18		0.380		14	2	0.154	
Creativity	NM				NM	2			NM	4		
Independence and *initiative*	4	2	0.001*	0.20	4	10	0.247		9	3	0.252	
Independent learning	3		0.949		2		0.268		9		0.358	
Numeracy	7	2	0.002*	0.20	8	14	0.835		17		0.076	
Verbal communication	9		<0.001*	0.22	13		0.468		6	7	0.071	
Presentation	14		0.095		17		0.066		4		0.306	
Organisation and time management	5	2	0.012*	0.15	7	5	0.002*	0.17	10	4	0.224	
Teamwork	3	4	0.001*	0.20	6	7	0.281		5	7	0.189	
Leadership	12		<0.001*	0.22	16		0.712		15		0.784	
Thinking and	1	3	0.209		3	17	0.081		7	9	0.187	
Problem-solving	2		0.854		1		0.131		13		0.013*	0.10
Use of tools, technology and software	10	2	0.164		9	5	0.000[b]*	–0.29[b]	16	4	0.336	
Written communication	11	4	<0.001[c]*	0.32[c]	15	4	0.006*	0.16	8	8	0.007*	0.11
Report writing	6		<0.001[c]*	0.36[c]	5		0.001*	0.19	2		0.041	
Other skills researched (but not badged):												
Ethical awareness and behaviour	13		<0.001*	0.21	14		0.221		3		0.149	
Experiment design	6		0.006*	0.17	11	11	0.413		12		0.680	
Literature research	15		<0.001*	0.35	12		0.028		1		0.831	

NM: not measured (in pre-badging survey); VLE: virtual learning environment.
Effect size is displayed for statistically significant results. 'No. badges': number of laboratories, workshops and assessments on which each badge was displayed.
[a]Rank order of % students selecting 'Some' or 'A lot' for 'Opportunity to develop this skill provided by Unit X' (Rank 1 = highest %).
[b]Decrease associated with loss of student access to technology/software in badging year.
[c]Uplift confounded with new assessment task/element in badging year.
*Statistically significant change

Table 3. Changes in student recognition of skills, post-badging, Warwick modules.

Skill badge displayed *Skill researched*	CH155				CH222				CH2A5[a]			
	Skill development rank[b]	No. badges	Sig. level	Effect size	Skill development rank[b]	No. badges	Sig. level	Effect size	Skill development rank[b]	No. badges	Sig. level	Effect size
Adaptability/flexibility	8	2	0.831		6	2	0.546		9		0.023	
Commercial awareness	13		0.695		17	2	0.001[c]*	0.22	13		0.003*	0.26
Creativity	NM	3			NM				NM	1		
Independence and *initiative*	3	3	0.297		8	6	0.091		4		0.009*	0.23
Independent learning	4		0.151		7		0.471		3		0.684	
Numeracy	7	11	<0.001*	0.29	6	10	0.343		11	1	0.013*	0.22
Verbal communication	8		0.894		11		0.043		8	1	0.001*	0.29
Presentation	12		0.738		14		<0.001[c]*	0.35	6		<0.001*	0.38
Organisation and time management	2	3	0.238		3	8	0.119		7	1	0.047	
Teamwork	5	6	0.117		5	3	0.008[c]*	0.18	10	1	<0.001[c]*	0.37
Leadership	11		0.762		15		0.070		14		<0.001[c]*	0.46
Thinking and	1	11	0.914		1	6	0.531		5	1	0.304	
Problem-solving	4		0.143		2		0.836		8		0.096	
Use of tools, technology and software	9	22	0.024		10	16	0.860		10	1	0.071	
Written communication	10	2	0.815		12		0.359		10	1	0.029	
Report writing	4		0.493		4		0.340		1		0.322	
Other skills researched (but not badged):												
Ethical awareness and behaviour	12		0.239		16		0.202		13		0.642	
Experiment design	6		0.191		13		0.442		12		0.023	
Literature research	6		0.094		9		0.550		2		0.059	

NM: not measured (in pre-badging survey); VLE: virtual learning environment.
Effect size is displayed for statistically significant results. 'No. badges': number of laboratories, workshops and assessments on which each badge was displayed.
[a]Badges awarded through VLE prior to survey.
[b]Rank order of % students selecting 'Some' or 'A lot' for 'Opportunity to develop this skill provided by Unit X' (Rank 1 = highest %).
[c]Uplift confounded with new assessment task/element in badging year.
*Statistically significant change

For CHM2911 and CH2A5, the uplift in recognition of skill development post-badging was more prevalent than for other units. The differences in implementation in these instances were that CH2A5 was the only unit awarding badges to students and CHM2911 was the only unit for which the coordinator asked TAs to mention the skills badges to students in each laboratory. Hence, it is possible that talking to students about the badges and/or awarding badges could strengthen the recognition of skill development associated with displaying badges.

The major themes from focus groups and interviews are presented in Table 4 and those from survey comments in Table 5.

Table 4. Themes from student and TA focus groups and interviews.

Theme	Students	TAs
Skills identified as developed in units	X	X
Skills identified as important in employment/after graduation	X	
Whether skills were noticed at the time of development and whether this was seen to be important	X	
Purposes of skills badges	X	X
Whether skills badges were noticed and/or given attention	X	X
Whether skills badges and skill recognition are beneficial	X	X
Suggested improvements to skills badges	X	X

TA: teaching associate.

Table 5. Themes from post-badging survey question 'Do you have any other comments about the skills badges?'

Theme	Example	Total no. comments	Average % comments per unit
Positive	'The badges were concise and relevant', 'Makes you aware of what you are learning', 'Will be helpful to look back as preparation for interviews'	97	34
Suggested improvements	'Describe their purpose more effectively please', 'Staff should emphasise these badges to enhance usefulness', 'Tell us about them more'	66	26
Negative	'Noticed them but they're useless and irrelevant', 'They seem pointless'	40	13
Neutral	'Didn't really find them to make a difference', 'It just didn't seem useful to me but weren't negative'	30	12
Didn't notice the badges	'I didn't know they were even there'	30	12
Didn't pay attention to them	'Didn't take much notice of them, ignored them for the most part'	11	4
Other/miscellaneous	'Only noticed when pointed out – Steve was only demonstrator that did'	9	5

Skills identified by students as developed

During focus group discussions and interviews, students named a wide range of skills as developed during their units including (in descending frequency): communication, teamwork, laboratory/practical, independence, application of theory, problem-solving, organisation and time management, critical thinking/analysis and workforce/life-relevant/employability skills. Some units were seen to develop presentation, confidence, adaptability, data analysis and experimental design skills, while software/coding skills were mentioned for CH155 and CH222 and numeracy for GEN2041. A small number of students identified leadership, precision, business/commercial awareness, ethics, creativity, initiative, safety, study skills, policy writing and stress management. Students recognised that a range of transferable skills were essential for the workforce. For example, one student listed: 'being independent . . . interpersonal skills are important. . . . as long as you have initiative . . . and the skill to . . . learn something that you don't know'.

There were a few differences in the frequency of specific skills identified. Critical thinking and teamwork were raised more often post-badging than pre-badging. Data analysis, independence/initiative, communication and real life/employability/workforce skills were identified more often in some laboratory contexts post-badging. These differences align with many skills for which there was an uplift in post-badging surveys (Tables 2 and 3), with the exception of critical thinking. While the latter was consistently strong in both surveys, students mentioned it more often in post-badging discussions.

Students' awareness of skill development

Most students indicated they were unlikely to notice skill development while carrying out a task. As several students expressed: 'Cause when you have to do the lab, you're focusing so much on doing all the stuff, you don't really stop to think' and 'As I was doing the assignments, that's not what I was thinking about. I was more so thinking about trying to get the assignments done'. A few students stated they might recognise skill development if it was their first time performing a task, especially new technical skills such as using different equipment.

Some recognised skill development in hindsight, when reflecting back over their course:

> For me, it's my fourth year, if I think back on it, I can see how I've changed, from first year to now. Like in first year, I wouldn't speak up about my opinions and stuff but I feel like group learning and a lot of group work and presentations . . . you really see yourself change and develop the skills.

Many students only seemed to identify skill development when prompted: 'Yeah, because what the uni started doing this year is put badges on all of the labs, that say teamwork and presenting skills or something, so you kind of know what you're supposed to be getting out of it'.

Prior to applying skills badges, such prompts were rarely provided within the curriculum. Survey data supported this beneficial impact of the badges (Figure 3), with 60%–80% students indicating skills badges helped them recognise skill development opportunities, 45%–65% indicating the badges prompted them to think about skills and many positive survey comments. For example, 'It's a great change as it shows you what skills you are learning in specific areas of the unit'. Students also noted they were prompted to recognise their skill development through participation in the study: 'They [gave] us a questionnaire a couple weeks ago that basically said . . . "are there any skills that you think you've picked up?" And then I was like, oh yeah, these are some of the skills'. Student: 'While I'm doing [the task], I'm thinking okay it's just a learning curve, I gotta get through this . . . and then I realize, oh I actually learnt something, I built a skill up along the way'. Facilitator: 'When did you have that realization?'. Student: 'Now! When I actually talk about it'.

Understanding the purpose of the badges

Students perceived the purpose of the badges as communicating the skills involved/required by a task, increasing awareness of skill development that could be gained from the task, linking tasks to real life and future employment and/or providing examples that could be used in job applications and interviews. The latter idea was often identified after communication from a TA in a laboratory or workshop or a unit coordinator in a lecture. Some students who were not introduced to the badges had no idea how to engage with them and dismissed them as worthless. It was not until a TA explained the badges that some students saw their value:

> I like [the badges] in hindsight. We talked about the badges in the last workshop [of another unit]. And so I'll probably use them later on now that I understand . . . how I am supposed to think about them . . . But I didn't appreciate them during the semester.

Benefits of the badges

Four main benefits of displaying skills badges were identified from student discussions and survey comments. These provide an explanation for why 48%–65% students indicated the badges were a positive addition to the unit (Figure 3):

- They alerted students to the skills required by a task, which helped some feel more prepared. 'The badges gave us an idea of what to [expect], without reading the protocol . . . it gives a nice indication of what you're doing'.
- They communicated a wider purpose for the task, which was especially beneficial for tasks students had felt were pointless. This increased some students' motivation. 'I like [the badges]. I feel like [they] at least tell me . . . why we are doing this instead of just giving you the questions and you don't know why we are even doing it in the first place'.
- They were a prompt to recognise which skills students had developed during a task, potentially leading to greater satisfaction. 'They helped you be more aware of what kinds of skills you were developing and at the end you could kind of see how that's actually true, like you've gained those skills. I think that's . . . a really good part of the unit'.
  'I do like the satisfaction of, when I'm doing my post lab, looking at the protocol again . . . and seeing, "Wow, I've done all those things." I like that sense of satisfaction from the badges'.
- They highlighted situations where students had developed a skill they could use 'in real life' and as examples for job applications: 'At the start of semester, I sort of looked at the [badges] and I was like 'I'm not going to pay any attention to them'. And then after I'd done each assignment, I sort of glanced at the [badges], and I was like, 'oh, yeah, I did that. I can use that as an example for how I learnt that skill' and actually it was a lot more useful than I thought it would be'.

Some students reported that the passive nature of the badges was a benefit because it allowed students to decide how much they wanted to engage with them: Student 1: 'Like those badges? Like that's really good because they're subtle'. Student 2: 'Doesn't take up my time either'. Student 3: 'You can take what you want out of [it]; if it is going to be helpful to you. But if you don't . . .'.

Engagement with the badges may help explain a statistically significant positive relationship between how frequently students noticed the badges, and their extent of agreement with positive statements about them. This occurred across all units except CH2A5 (large effect size). It is

possible that the more students believed the badges were beneficial, the more likely they were to notice them.

Neutral or negative reactions

On average, 21% students did not recognise any benefits of the skills badges or find them meaningful (Figure 3). As one student commented 'They were great if you had an understanding of what they meant'. A criticism was that some were used unnecessarily, for example, displaying a 'teamwork' badge on a team-centred task or a 'computer skills' badge on a computer task. As one student said 'I can figure that out'. Students also felt that some badges were repeated too many times in a unit. Some students felt they had good consciousness of their skill development and did not need the badges or that they would prefer employability initiatives such as internships, authentic tasks or career examples. A few students felt the badges were childish: 'The badges themselves, I found a bit patronising, childish . . . I feel they're akin to girl scout badges'.

TAs' reactions

There were mixed approaches towards the badges among TAs. Some laboratory TAs were focused on ensuring students' understood technical tasks and did not pay attention to the badges. They were unsure of their impact but expressed that they were not a negative addition: 'I think not many students would look at them. But I think the ones that do want to know how it relates to other learning or past uni, that it's really useful for them'.

Other TAs identified several benefits including helping students understand what they could gain from tasks beyond technical content; clarifying the purpose of an activity; highlighting which skills are important beyond university and assisting with preparation for work. Such TAs felt that the badges were beneficial because many students were not conscious they were developing transferable skills: 'I think anything that helps to kind of emphasize that they are learning skills more broadly than just specific facts is really useful'. 'It's important for them to identify what skills they can take away from it and . . . how to package [this] in a CV and sell themselves when they apply for jobs'.

Displaying skills badges also impacted some TAs' practices. Several said the badges prompted them to communicate to students that they are developing important transferable skills during tasks: 'If [the badges] were not there I would have never thought that I need to tell this to my students . . . It's a prompt for me [to] step up and tell the students'. Some TAs commented that the badges caused them to think differently about their teaching; that it was important they ensured their teaching approach helped students develop the skills: 'I would say that it has caused me to realize more the importance of delivering the skills that are highlighted. So it got me thinking as well and I guess it's sort of shaped my teaching in a way'.

Two TAs raised concerns: one thought that if the badges were promoted more actively, students might conclude they need to worry about their employability. Another pointed out that not all skills involved in a task or employment were represented by the badges and these may be overlooked.

Suggestions for improvement

The most requested improvement to the badges by students was to have staff 'talk about them': 'Just bring them to people's attention. I don't remember anyone ever pointing out they existed'. Many students suggested staff should draw attention to the relevant skills at the beginning of a task:

> I think even at the start of every lab, if the TA is just like, "Oh, these are the skills that you're going to gain today," as simple as that, because it's going to be in your mind so you're going to be thinking about it as you go along.

However, some students cautioned that they would not want to hear about the same skills repeatedly. A range of skills should be highlighted across tasks, with obvious skills like teamwork or report writing only highlighted when incorporated in a new way.

Some students recommended incorporating skills discussions into lectures, workshops or post-lab discussions, to crystallise the skills gained from major tasks:

> I think having this discussion is also really helpful . . . like hearing what other people have to say and actually really concentrating on those skill [badges] rather than just sort of briefly remembering 'Oh, yeah. I learnt that skill'. Now . . . I'm more likely to remember that I used those skills in this subject and I have examples of how I've learned those skills.

Some students and TAs suggested incorporating reflective writing tasks to strengthen skill recognition and articulation. Such an approach would also help them gain more value from their experiences (Boud et al., 2013). Other suggestions for increasing the badges' impact were to incorporate them in multiple units; have staff provide feedback on students' skills; add a question about skills to pre-laboratory tasks and to provide a summary of the skills involved in the unit, linked to tasks. Most students preferred the badges to be coloured, so they stand out.

Awarding badges for completing a task

At the time of the survey, 97% of students taking Warwick module CH2A5 had been awarded eight badges through the VLE. While this module had the lowest number of students not noticing the badges (4%, Figure 2), and high agreement that the badges helped recognise skill development opportunities (75%, Figure 3), negative reactions to the badges were also highest of all units, with 30% of students not finding them meaningful and 14% saying they were unhelpful/distracting. Students expressed that receiving badges as a 'participation award' was unhelpful. They reminded them of a 'school effort award' and would be more meaningful if they were received on merit, with opportunities for further improvement. They suggested having several levels of badges, with multiple opportunities to develop each skill and receive and implement meaningful feedback. Such an approach would require formal assessment of skills at multiple points in the curriculum.

Conclusion

This study suggests that while undergraduates value skills and can identify skills improved through the curriculum during a reflective discussion, they are unlikely to be conscious of such skill development unless prompted. Displaying transferable skills badges on learning resources or assessment tasks prompts many students to become more aware of skill enhancement, helping improve the poor recognition of much curriculum-embedded skill development reported in the literature. The badges prompt students to think about skills and increase recognition of the improvement of some skills, particularly those less obvious to them. Other benefits can include clarification of the purpose of tasks, leading to increased motivation or engagement, greater satisfaction after task completion, identification of examples of skills students can share in job applications and providing links between the curriculum and employability as called for in the literature.

Understanding the purpose of the badges and how to use them is key to students engaging with them. A key factor for increasing the impact of the badges is for teaching staff to talk about them.

They should be introduced on unit commencement, explaining that their purpose is to highlight skills that are required in the workplace, research and other roles. The benefits of recognising opportunities to develop a skill, increased confidence in each skill, and the use of these experiences as examples in job applications and interviews, should be clearly articulated to students. Such an introduction provides purpose and authority for the badging initiative. Students suggested that TAs in teaching laboratories or workshops should briefly refer to the relevant badges at the start of each session, link them to activities and emphasise why they are important. Students are likely to gain the most from their experiences and the badges when there are opportunities to reflect on and articulate the skills highlighted. This could be achieved by facilitating discussions about skill development during the course or including a written reflective task.

This study also suggests that displaying skills badges may impact some teaching staff by prompting them to communicate to students that they are building transferable skills. It may also prompt some staff to reflect on their teaching practice and adjust their approach to provide students with sufficient opportunities to develop the stated skills. This highlights the benefits of implementing initiatives that are noticeable to staff and students. However, not all TAs understood the purpose of the badges or the essential role they play in helping students notice and understand them. Unit coordinators need to explain the purpose of the badges and their potential impact to TAs and academics who teach in the unit, providing information for them to communicate to students, with reminders.

The following recommendations are made for how to display skills badges to maximise their impact:

- Display the badges at the start of each class, in an assignment's instructions and in workshop/laboratory manuals/instructions.
- Show selected badges, rather than over-using badges for prevalent skills. Prioritise badging skills that are not self-evident. For obvious skills such as teamwork and written communication, highlight them when the task offers a new approach.
- Where instructions cover multiple pages, display pertinent badges within appropriate sub-sections.
- Provide a summary of the skills developed in the unit on the VLE and in the introduction to workshop/laboratory manuals, preferably linked to relevant tasks.
- Implement the badges across multiple units so that students recognise and benefit from the skills developed throughout their course.

Finally, results suggest that undergraduates would prefer to receive skills badges on merit rather than for completing a task.

There are, however, limitations to this study. Awarding badges was trialled with only one unit. In all but one unit, only one cohort of students experienced the displayed badges. The focus group and interview participants were volunteers and hence their views may not be representative of their cohort. The survey provided students with a list of skills, which was identified by some as a prompt for recognising skill development. The badges were evaluated only in Australia and the United Kingdom, with undergraduates and in a small number of disciplines. They were only evaluated at two highly ranked universities and only in one first year unit. Future work should involve evaluating the skills badges with additional cohorts, more first year students, in further disciplines, in additional countries and university contexts and among postgraduates. It would also be useful to explore whether responses to the badges differ by gender, student type (domestic/international) or student background (socioeconomic status and employment experience).

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This part of the study ascertained the extent to which displaying skills badges on learning resources or assessment tasks assisted students to recognise curriculum-embedded skill development and identified approaches to implementing the badges to maximise their effectiveness. The key findings were:

Science undergraduates are unlikely to be conscious of transferable skill development unless prompted. Displaying skills badges on curriculum tasks increased students' recognition of the development of some transferable skills, particularly those that were less obvious to students initially.

Displaying skills badges in the curriculum also helped students understand that skill development was a purpose for and outcome of tasks, which many had not previously recognised, leading to improved motivation and satisfaction. Other benefits of the badges included alerting students to the skills required by a task, which helped them feel more prepared, making an explicit link between degree tasks and 'real life' and highlighting specific examples of skills that students could use in the employment process. Thus displaying skills badges provided an explicit link between the curriculum and employability as called for in the literature.

Some TAs were unaffected by the skills badges, remaining focused on discipline content and skills. However some were prompted by the badges to talk to students about skills and to refocus their approach to ensure they helped students develop the highlighted skills.

Not all students recognised the purpose of the badges and needed teaching staff to explain this to them. To maximise the impact of the badges, it is important that academics and TAs introduce the badges at the start of a teaching period and explain their purpose and benefits. It is also desirable for TAs to draw students' attention to the relevant skills when beginning each session and link them to activities, so students can be conscious of their skill development during tasks. Academics will need to specifically ask TAs to share this information with students, as many TAs did not understand their role in helping students notice and understand the badges.

When implementing skills badges, it is important to prioritise badging skills that are not self-evident and to not over-use badges for prevalent skills. Implementing the badges across multiple units will help students recognise skills developed throughout their degree.

These findings confirm that skills badges when displayed on curriculum tasks provide sign posts that broaden students' recognition of in-curriculum skill development and can result in other important benefits for students and TAs. However, displaying skills badges alone does not develop students' ability to articulate the recognised skills. Chapter 6 will present the results of combining skills badges with reflection in the curriculum to explore whether this approach can increase students' ability to both recognise and articulate a greater breadth of in-curriculum skill development.

6 Results of the skills reflection with badging intervention

This chapter summarises the results from the investigation of the impact of students writing reflections on skills used or developed during their laboratory tasks in two second year chemistry units in which skills badges were displayed at Monash University. A summary of the post-intervention survey data is presented, as well as statistical analyses comparing the post-intervention survey data with that collected prior to adding the reflection task. Analyses of relationships between key elements of the survey instrument are also reported. Figure 6.1 summarises the survey data and analyses that are presented in this chapter, including the comparisons that are made with pre- and post-badging data collected in the previous project element ("The impact of badging employability skill development opportunities in the science curriculum", Chapter Five).

Analysis of data from student and TA focus groups are also presented and triangulated with the survey data.

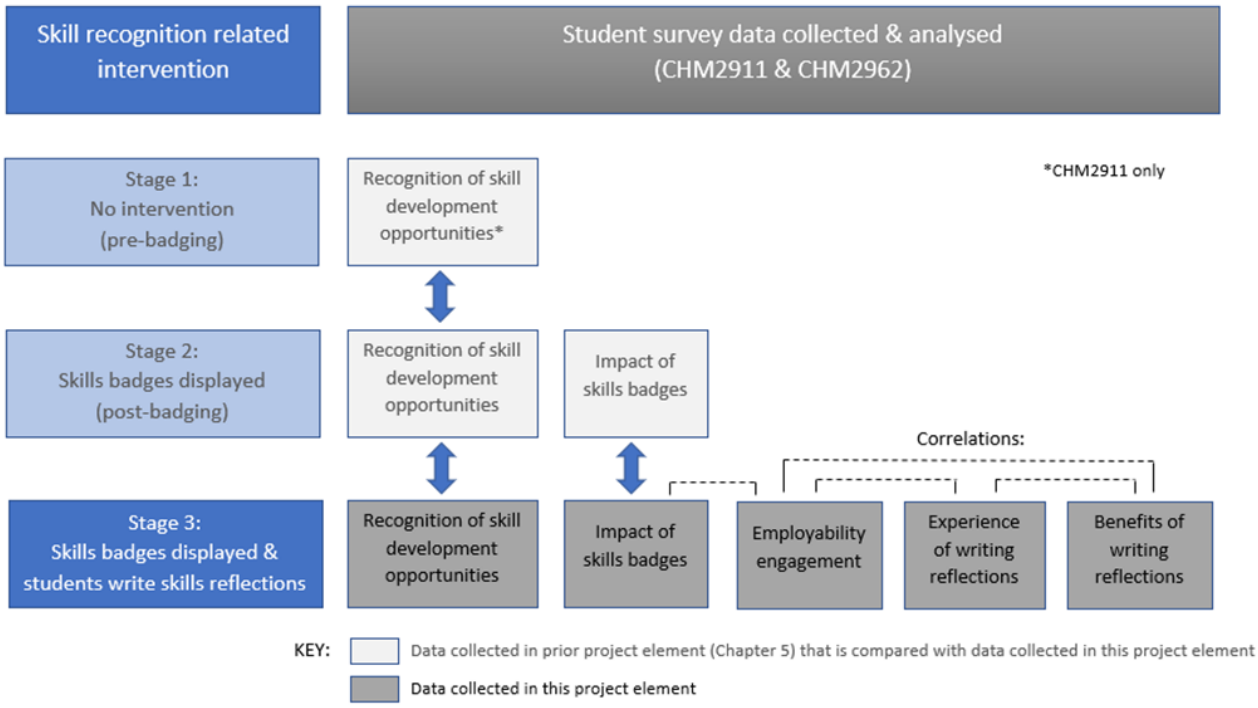

Figure 6.1 Summary of survey data and analyses on the skills reflection with badging intervention

Note: Each of Stages 1, 2 and 3 was run in a separate academic year, with a different student cohort

6.1 Student survey results

Survey results are grouped into five main categories in accordance with the main survey sections: students' experience of writing skills reflections, their understanding of and engagement with employability, the benefits of writing skills reflections, recognition of skill development opportunities and the impact of displaying skills badges (as shown in Figure 6.1, Stage 3).

6.1.1 The student experience of writing skills reflections

Student responses to statements about their experience of writing skills reflections are summarised in Table 6.1. At least two thirds of students found it easy to identify a skill to write about and only 16-23% students found it difficult to write skills reflections, with 70-75% agreeing that it got easier with practice. However, 35-38% of students disliked writing the reflections. It appeared that many

students were not given detailed information about the task, with a third or fewer students agreeing that their TA had explained the purpose of writing the reflections and 38-50% agreeing that they knew where to find help with the reflections.

Overall, the responses were similar across both units, with the exception of 'Writing skills reflection was difficult'. A larger proportion of CHM2911 students agreed with this statement and fewer students disagreed with it, indicating more CHM2911 than CHM2962 students may have struggled with the skills reflection task.

Table 6.1 Student survey responses on their experience of writing reflections

	Statement	% students agreeing		% students disagreeing	
		CHM2962	CHM2911	CHM2962	CHM2911
Ease of writing reflections	Writing reflections got easier as I did more of them	70%	75%	10%	4%
	It was easy to identify a skill to write about	67%	72%	13%	12%
	I liked writing skills reflections	35%	43%	38%	35%
	Writing skills reflections was difficult*	16%	23%	59%	45%
Information provided	I knew where to find help with skills reflections	38%	50%	33%	25%
	My TA explained the purpose of skills reflections	29%	33%	51%	42%

*A significant difference is noted between CHM2962 and CHM2911 responses for this statement, p=0.008, effect size = 0.12.

6.1.2 Student understanding of and engagement with employability

Table 6.2 summarises student responses to statements about their understanding of and engagement with employability. Most students (84-87%) agreed that it's important to start preparing immediately for a job or career, with just over three quarters believing they understood why it's important to be able to articulate their skills. However, nearly 30% of students agreed with the statement "all that matters now is succeeding in my degree and doing well", indicating they are not really engaged with employability at this stage. The fact that only half of students disagreed with this statement also suggests that some students are 'in two minds' about whether or how much they should give attention to jobs or careers at this stage of their degree, despite believing it is important. Responses to these questions were very similar across the two units.

Table 6.2 Student survey responses on understanding of and engagement with employability

	Statement	% students agreeing		% students disagreeing	
		CHM2962	CHM2911	CHM2962	CHM2911
Employability understanding and engagement	It is important to start preparing now for a job/career	84%	87%	4%	1%
	I understand why it's important to be able to talk/write about my skills	76%	80%	7%	5%
	All that matters now is completing my degree & doing well	28%	28%	52%	54%

Note: There is no significant difference between CHM2962 and CHM2911 responses for these statements

6.1.3 Student perceptions of the benefits of writing skills reflections

Student responses to statements about the benefits of writing skills reflections are presented in Table 6.3. Most students believed they had benefited in some way from writing the skills reflections. Very few students indicated they had received none of the potential benefits listed in the questionnaire: an average of 8% of CHM2962 students selected 'not at all' for the seven listed benefits (range 6-12%) and an average of 5% of CHM2911 students (range 3-7%).

Table 6.3 Student survey responses to statements on the impact of writing skills reflections

Writing skills reflections helped me:	CHM2962			CHM2911			Difference between units	
	A little	To some extent	A lot	A little	To some extent	A lot	Sig. level	Effect size
think about skills, not only the unit content*	26%	49%	18%	23%	49%	28%	0.003	0.14
identify some skills I could improve*	24%	50%	18%	19%	53%	28%	0.001	0.15
identify some skills I have developed*	27%	53%	14%	17%	55%	22%	0.009	0.12
develop my ability to express my skills in words*	25%	49%	18%	20%	52%	26%	0.007	0.13
Identify some examples of my skills I could use in job applications or interviews*	23%	49%	19%	13%	43%	34%	0.001	0.16
make more sense of my experiences	29%	45%	16%	20%	49%	23%	0.013	
get more out of this unit*	36%	36%	15%	28%	43%	22%	0.004	0.14

*There is a statistically significant difference between CHM2962 and CHM2911 responses for these statements

An average of 64% of CHM2962 students and 75% of CHM2911 students indicated they had benefited 'to some extent' or 'a lot' in each of the seven specified ways, as shown in Figure 6.2. Skills reflection appeared to benefit the greatest number of students through developing their ability to articulate their skills, identifying examples they could use in the recruitment process, identifying skills they could improve or had developed and thinking about skills, not simply the unit content (67-69% CHM2962 and 77-81% CHM2911 students). 61-72% of students also felt writing skills reflections had helped them to some extent or a lot to make more sense of their experiences.

Overall, CHM2911 students believed they had benefited a little more from the skills reflection task than CHM2962 students with the exception of 'Make more sense of my experiences'.

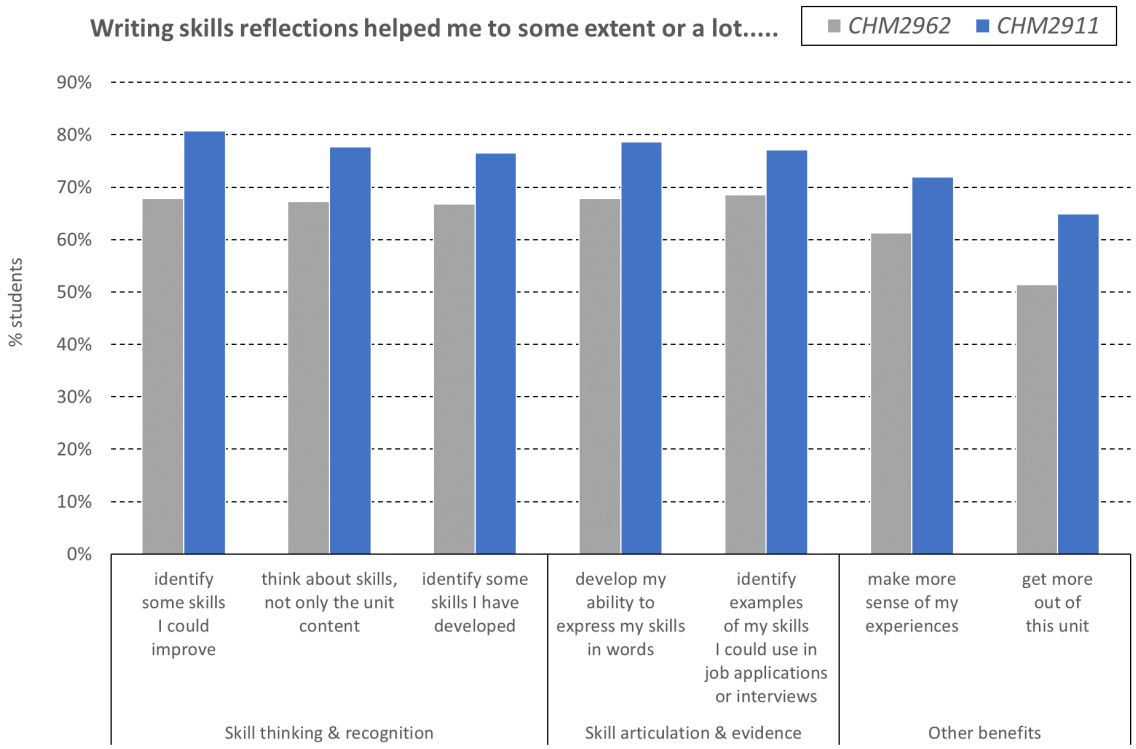

Figure 6.2 Percentage of students that benefited 'to some extent' or 'a lot' from writing skills reflections

6.1.4 The relationship between students' reflection experiences and the perceived benefits of writing reflections

Table 6.4 shows the correlations between students' perceptions of the benefits of writing skills reflections and their responses to statements about their experience of writing reflections. Responses to the experience statements that correlated with responses to six or seven of the benefits of skills reflections in both units were 'I liked writing skills reflections' (predominantly medium correlations), 'writing reflections got easier as I did more of them' (small to medium correlations) and 'my TA explained the purpose of writing skills reflections' (small to medium correlations). Whilst correlation does not imply causation, results suggest that it is possible that having a positive attitude towards writing the reflections and/or understanding the purpose behind them may increase students' likelihood of realising benefits from the skills reflection task.

'I knew where to find help with skills reflections' was correlated with the benefits 'helped me make more sense of my experiences', 'develop my ability to express my skills in words' and 'get more of the unit' (small to medium correlations). This could suggest that being given more information about how to reflect may have helped some students express themselves and obtain more meaning from their reflections.

Table 6.4 Spearman correlation coefficients between the student experience of writing reflections and the perceived impact of writing the reflections, for CHM2962 and CHM2911^

Student experience of writing reflections:	Writing skills reflections helped me:						
	Identify skills developed	Identify skills could improve	Think about skills, not only content	Make more sense of experiences	Develop ability to express skills in words	Identify examples of skills for job applications & interviews	Get more out of unit
Writing reflections got easier as I did more of them	0.38*, 0.41*	0.34*, 0.39*	0.40*, 0.19*	0.40*, 0.21*	0.43*, 0.44*	0.39*, 0.23*	0.36*, 0.11
It was easy to identify a skill to write about	0.25*, 0.17	0.17*, -0.002	0.22*, -0.02	0.21*, 0.08	0.25*, 0.03	0.29*, 0.06	0.15, -0.04
I liked writing skills reflections	0.47*, 0.42*	0.47*, 0.39*	0.37*, 0.28*	0.44*, 0.37*	0.39*, 0.41*	0.36*, 0.27*	0.48*, 0.35*
Writing skills reflections was difficult	-0.08, -0.06	-0.04, -0.002	-0.08, -0.01	-0.10, -0.04	-0.15, -0.05	-0.13, -0.08	-0.02, 0.06
I knew where to find help with skills reflections	0.27*, 0.18	0.28*, 0.19	0.31*, 0.13	0.34*, 0.28*	0.36*, 0.32*	0.32*, 0.15	0.30*, 0.24*
My TA explained the purpose of skills reflections	0.29*, 0.27*	0.30*, 0.29*	0.32*, 0.23*	0.32*, 0.32*	0.31*, 0.23*	0.27*, 0.10	0.34*, 0.30*

^The first correlation coefficient magnitude listed is for CHM2962 and the second is for CHM2911
*Correlation coefficient was statistically significant
Grey highlighting indicates at least one of the units showed a significant medium correlation and the other at least a significant small correlation

6.1.5 The relationship between students' employability engagement and the perceived benefits of writing reflections

Table 6.5 shows the correlations between students' perceptions of the benefits of writing skills reflections and their responses to statements about their engagement with employability. Responses to the statement 'I understand why it's important to be able to talk/write about my skills' correlated with responses to all seven of the benefits of skills reflections in both units (predominantly medium correlations). These results suggest that it is possible that understanding the reasons why they need to be able to communicate about their skills may increase students' likelihood of realising benefits from the skills reflection task.

Table 6.5 Spearman correlation coefficients between student employability engagement and the perceived benefits of writing the reflections, for CHM2962 and CHM2911^

Employability engagement:	Writing skills reflections helped me:						
	Identify skills developed	Identify skills could improve	Think about skills, not only content	Make more sense of experiences	Develop ability to express skills in words	Identify examples of skills for job applications & interviews	Get more out of unit
It is important to start preparing now for a job/career	0.25*, 0.12	0.28*, 0.14	0.30*, 0.09	0.26*, 0.02	0.25*, 0.15	0.30*, 0.30*	0.24*, 0.05
I understand why it's important to be able to talk/write about my skills	0.34*, 0.36*	0.33*, 0.30*	0.43*, 0.32*	0.26*, 0.31*	0.37*, 0.30*	0.39*, 0.39*	0.32*, 0.28*
All that matters now is completing my degree & doing well	0,02, -0.12	0.03, -0.11	0.001, -0.05	0.06, 0.04	0.05, 0.08	0.01, 0.01	0.03, -0.07

^The first correlation coefficient magnitude listed is for CHM2962 and the second is for CHM2911
*Correlation coefficient was statistically significant
Grey highlighting indicates at least one of the units showed a significant medium correlation and the other at least a significant small correlation

6.1.6 The relationships amongst measures of students' experience of writing reflections

The correlations between students' responses to each of the statements about the experience of writing skills reflections are presented in Table 6.6. These indicate that students were more likely to find it easier with time to write the reflections if they liked writing the reflections, found it easy to identify a skill to write about or knew where to find help with the skills reflections. This suggests that perhaps easily identifying skill development opportunities (through the displayed skills badges) or providing a reflection 'help' sheet may have assisted some students with writing the reflections. There was a medium correlation between 'My TA explained the purpose of skills reflections' and 'I knew where to find help with skills reflections'. This suggests that TAs could have an important role in communicating this information to students, which in turn may increase the benefits some students experience from the skills reflection task, as noted in section 6.1.4

Table 6.6 Spearman correlation coefficients amongst the measures of student experience of writing reflections, for CHM2962 and CHM2911^

	Writing reflections got easier as I did more of them	It was easy to identify a skill to write about	I liked writing skills reflections	Writing skills reflections was difficult	I knew where to find help with skills reflections	My TA explained the purpose of skills reflections
Writing reflections got easier as I did more of them	1, 1					
It was easy to identify a skill to write about	0.44*, 0.31*	1, 1				
I liked writing skills reflections	0.40*, 0.36*	0.21*, 0.08	1, 1			
Writing skills reflections was difficult	-0.27*, -0.23*	-0.47*, -0.41*	-0.06, -0.0.10	1, 1		
I knew where to find help with skills reflections	0.30*, 0.25*	0.25*, 0.10	0.24*, 0.21*	-0.13, -0.07	1, 1	
My TA explained the purpose of skills reflections	0.20*, 0.18	0.07, 0.02	0.20*, 0.20*	0.02, -0.03	0.40*, 0.37*	1, 1

^The first correlation coefficient magnitude listed is for CHM2962 and the second is for CHM2911.
*Correlation coefficient was statistically significant.
Light grey highlighting indicates at least one of the units showed a significant medium correlation and the other at least a significant small correlation.

6.1.7 The relationships amongst measures of students' engagement with employability

The correlations between students' responses to each of the statements about engagement with employability are presented in Table 6.7. The notable relationship here is the strong correlation for both units between 'I understand why it's important to talk/write about my skills' and 'It is important to start preparing now for a job/career'. This indicates there could be a link between the former understanding and student engagement with some employability building activities or tasks at university, perhaps suggesting that some students recognise skills and the ability to articulate them are necessary for employment, and hence recognise the importance of preparation prior to graduation, as such skills cannot be developed 'overnight'.

Table 6.7 Spearman correlation coefficients amongst the measures of engagement with employability, for CHM2962 and CHM2911^

	It is important to start preparing now for a job/career	I understand why it's important to be able to talk/write about my skills	All that matters now is completing my degree & doing well
It is important to start preparing now for a job/career	1, 1		
I understand why it's important to be able to talk/write about my skills	0.50*, 0.50*	1, 1	
All that matters now is completing my degree & doing well	-0.29*, -0.24*	-0.14, -0.12	1,1

^The first correlation coefficient magnitude listed is for CHM2962 and the second is for CHM2911.
*Correlation coefficient was statistically significant.

Light grey highlighting indicates at least one of the units showed a significant medium correlation and the other at least a significant small correlation.

There is also a negative correlation between 'All that matters now is completing my degree and doing well' and 'It is important to start preparing now for a job/career'. This makes sense, since if all that matters now to a student is completing their degree then they are unlikely to agree it is important to start preparing now for a job or career.

6.1.8 The relationship between student engagement with employability and their experience of writing reflections

The correlations between students' responses to the statements about employability engagement and their experiences of writing skills reflections are presented in Table 6.8. These indicate that students were more likely to find it easier with time to write the reflections if they understood why it is important to be able to express their skills and are engaged with job/career preparation (small to medium correlation). Understanding why the ability to express skills is important was also correlated with liking to write the reflections and finding it easy to identify a skill to write about (small to medium correlation) indicating that understanding this element of employability may have increased some students' engagement or positive persistence with the task. There was also a small to medium correlation between responses to 'My TA explained the purpose of skills reflections' and 'I understand why it's important to be able to talk/write about my skills' suggesting again that TAs may have an important role in helping some students understand this key aspect of employability and thus potentially engage with and benefit from the skills reflection task.

Table 6.8 Spearman correlation coefficients between the measures of student experience of writing reflections and the measures of employability engagement, for CHM2962 and CHM2911^

Employability understanding & engagement:	Student experience of writing skills reflections:					
	Writing reflections got easier as I did more of them	It was easy to identify a skill to write about	I liked writing skills reflections	Writing skills reflections was difficult	I knew where to find help with skills reflections	My TA explained the purpose of skills reflections
It is important to start preparing now for a job/career	0.30*, 0.26*	0.30*, 0.15	0.17*, 0.07	-0.24*, -0.17	0.15*, 0.07	0.12, 0.17
I understand why it's important to be able to talk/write about my skills	0.34*, 0.26*	0.35*, 0.24*	0.22*, 0.27*	-0.20, -0.16	0.15*, 0.09	0.28*, 0.32*
All that matters now is completing my degree & doing well	-0.10, -0.07	-0.17*, -0.11	0.05, -0.10	0.24*, 0.16	0.08, 0.07	0.14, -0.01

^The first correlation coefficient magnitude listed is for CHM2962 and the second is for CHM2911.
*Correlation coefficient was statistically significant.
Light grey highlighting indicates at least one of the units showed a significant medium correlation and the other at least a significant small correlation.

6.1.9 Recognition of unit skill development opportunities with and without skills reflection

The questionnaire asked students to what extent each unit had offered them the opportunity to develop 19 specific skills. Table 6.9 summarises the change in responses of CHM2911 students who had experienced the written skills reflections and skills badges (project Stage 3)

compared with those from prior years who had experienced the skills badges alone (no reflections; project Stage 2) or no skill recognition related intervention (project Stage 1). (Note that data from Stage 1 and Stage 2 is from Chapter 5, "The impact of badging skills development opportunities in the curriculum").

Table 6.9 CHM2911: Change in student recognition of skill development opportunities, post-badging and post-reflection

Skill badge displayed, *Skill researched*	Skill development rank before badging^	No. badges	Post-badging (Stage 2) vs pre-badging (Stage 1)		Post-reflection & badging (Stage 3) vs post-badging (Stage 2)		Post-reflection & badging (Stage 3) vs pre-badging (Stage 1)	
			Sig. level*	Effect size	Sig. level	Effect size	Sig. level*	Effect size
Commercial awareness	12	2	0.002	0.19	0.028		<0.001	0.31
Independence & *initiative*	4	2	0.001	0.20	0.623		0.003	0.17
Independent learning	3		0.949		0.046		0.061	
Numeracy	7	2	0.002	0.20	0.005	0.16	<0.001	0.38
Organisation & time management	5	2	0.012	0.15	0.258		<0.001	0.22
Teamwork	3	4	0.001	0.20	0.608		0.003	0.17
Leadership	12		<0.001	0.22	0.937		<0.001	0.24
Thinking &	1	3	0.209		0.469		0.035	
Problem solving	2		0.854		0.144		0.088	
Use of tools, technology & software	10	2	0.164		0.166		0.002	0.18
Written communication	11	4	<0.001#	0.32#	0.988		<0.001#	0.33#
Report writing	6		<0.001#	0.36#	0.611		<0.001#	0.34#
Other skills researched (but not badged)								
Adaptability/flexibility	8		0.052		0.177		<0.001	0.20
Creativity	NA		NA		0.039		NA	
Ethical awareness & behaviour	13		<0.001	0.21	0.170		<0.001	0.27
Experiment design	6		0.006	0.17	0.681		0.014	0.14
Literature research	15		<0.001	0.35	0.284		<0.001	0.40
Verbal communication	9		<0.001	0.22	0.347		<0.001	0.26
Presentation	14		0.095		0.380		0.004	0.17

#Change in skill recognition is confounded with change in assessment (two full laboratory reports added)
*Shading denotes a statistically significant change
NA = Not Applicable (because no data was collected on this skill in the pre-badging survey)
Note: Stage 1 and Stage 2 data is from Chapter 5

Figure 6.3 presents the proportion of CHM2911 students responding that they had the opportunity to develop each skill 'to some extent' or 'a lot' at each stage of the project. Writing skills reflections appeared to strengthen CHM2911 student recognition of the opportunity to develop some of the skills that were less well recognised prior to the intervention (skills where fewer than 80% students believed the unit had offered 'some' or 'a lot' of opportunity to develop them). One skill (numeracy) showed a statistically significant uplift in recognition amongst students who had written skills reflections in the presence of skills badges, compared with those who had experienced only the displayed badges. When compared with the pre-intervention baseline (no skills badges or reflection), post-reflection there was a larger effect size for increased recognition for several of the less well recognised skills compared with when badges were applied alone (commercial awareness and numeracy; increased from small to medium effect size). Several additional skills also reached

statistical significance for increased recognition post-reflection and badging, than post-badging alone (use of tools, technology and software, adaptability/flexibility and presentation skills).

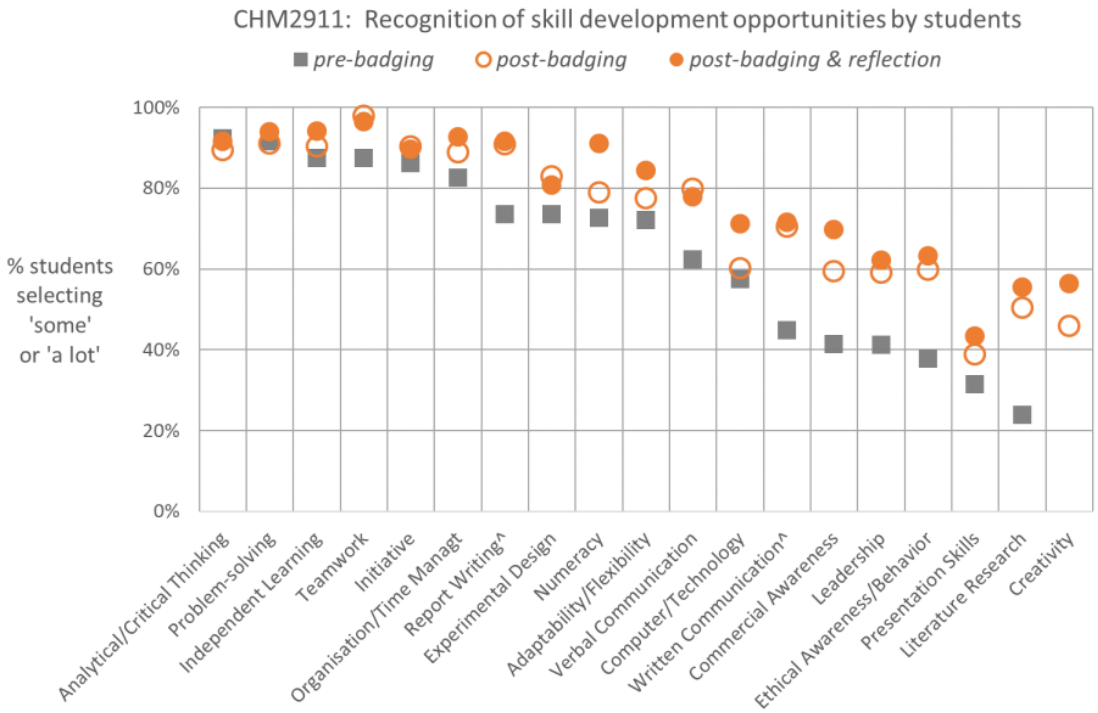

Figure 6.3 Percentage of CHM2911 students believing the unit offered 'some' or 'a lot' of opportunity to develop each skill, pre- and post-badging and reflection interventions

For CHM2962, no pre-badging data was available and so skill recognition 'post-reflection and badging' can only be compared with responses 'post-badging', with this data presented in Table 6.10. Whilst one skill showed a statistically significant uplift in recognition post-reflection and badging (report writing) compared with post-badging, all observed skill recognition changes were confounded with changes in assessment tasks. Hence it is not possible to make conclusions about the impact of writing skills reflections on CHM2962 students' recognition of specific skills.

Table 6.10 CHM2962: Change in student recognition of skills, post-badging and reflection

Skill badge displayed, *Skill researched*	Skill development rank post-badging (Stage 2)^^	No. badges	Post-reflection & badging (Stage 3) vs post-badging (Stage 2)	
			Sig. level	Effect size[b]
Commercial awareness	15	2	0.013	0.12
Independence & *initiative*	2	4	<0.001#	-0.15#
Independent learning	7		0.539	
Numeracy	14	1	0.232	
Verbal communication	9	1	0.006#	-0.13#
Presentation	4		0.001#	-0.15#
Organisation & time management	3	1	0.547	
Teamwork	1	2	0.112	
Leadership	11		0.002#	-0.15#
Thinking & Problem solving	5	1	0.639	
	6		0.723	
Use of tools, technology & software	12	2	0.154	
Other skills researched (but not badged)				
Adaptability/flexibility	6		0.269	
Creativity[a]	10	(-2)[a]	<0.001#	-0.19#
Ethical awareness & behaviour	17		0.495	
Experiment design	8		0.343	
Literature research	16		0.092	
Written communication	13		0.942	
Report writing	5		0.008	0.12

[a]Badged on two assignments in 2018 but not in 2019

[b]A negative effect size has been used to indicate a decline in skill recognition in Stage 3 (post reflection and badging) compared with Stage 2 (badging only)

#Change in skill recognition is confounded with change in assessment tasks. (A team-based video making assignment was removed and replaced by two individual written communication assignments (an infographic and food product data sheet)).

*Shading denotes a statistically significant change

Note: Stage 2 data is from Chapter 5

6.1.10 Student responses about the skills badges with and without skills reflection

The questionnaire asked students to what extent they agreed with seven statements about the impact of the skills badges. Table 6.11 summarises the responses to these statements from students who had experienced the skills reflection task as well as the displayed badges. In both units, a majority of students felt the badges helped them to recognise some skills they could gain from the unit, prompted them to think about skills, not only the course content, and were a positive addition to the unit (53-66% CHM2962 and 69-81% CHM2911 students). Half of CHM2962 and two thirds of CHM2911 students also felt the badges were a positive addition to the unit. A third of students felt the badges made no difference to them but very few thought they were unhelpful or distracting (6-10%). Despite the context of the written reflections, 16% students in both units lacked understanding of the meaning and/or purpose of the badges.

In line with student responses to the impact of writing skills reflections, more CHM2911 than CHM2962 students responded positively about the badges and more disagreed that the badges were unhelpful.

Table 6.11 Student responses to statements about the impact of skills badges when coupled with writing skills reflections

Statement type:	***Displaying skills badges on unit materials…***	% students agreeing		% students disagreeing		Difference between units	
		CHM2962	CHM2911	CHM2962	CHM2911	Sig. level	Effect size
Positive	helped me to recognise some skills I could gain from this unit*	66%	81%	10%	4%	<0.001	0.16
	prompted me to think about skills, not only the course content*	59%	69%	12%	6%	0.008	0.12
	was a positive addition to the unit*	53%	68%	8%	2%	0.001	0.16
	increased the value I saw in this unit*	36%	52%	16%	8%	0.001	0.15
Neutral	made no difference to me	34%	30%	38%	47%	0.137	
Negative	wasn't meaningful to me – I wasn't sure what they meant or why they were there	16%	16%	54%	61%	0.142	
	was unhelpful because it distracted me from the unit content / tasks*	10%	6%	63%	77%	0.002	0.15

*A significant difference is noted between CHM2962 and CHM2911 responses for these statements

As noted in Figure 6.1 (Stage 2), in a prior academic year the skills badges were displayed on CHM2962 and CHM2911 curriculum materials, but students were not asked to write reflections about their skills. Figure 6.4 shows the frequency with which students noticed the skills badges, when coupled with writing skills reflections, compared with when the badges were used alone. Table 6.12 summarises student responses to statements about the impact of the skills badges, with and without the skills reflection task.

There was no statistically significant change in the frequency with which students noticed the badges after the addition of the reflective task and there was no change in CHM2911 student views of the impact of the skills badges when combined with writing skills reflections. However, overall the skills badges were a little less appreciated by CHM2962 students when combined with reflection, with fewer CHM2962 students feeling the badges increased the value of the unit and more students thinking the badges were unhelpful during the semesters CHM2962 students wrote skills reflections.

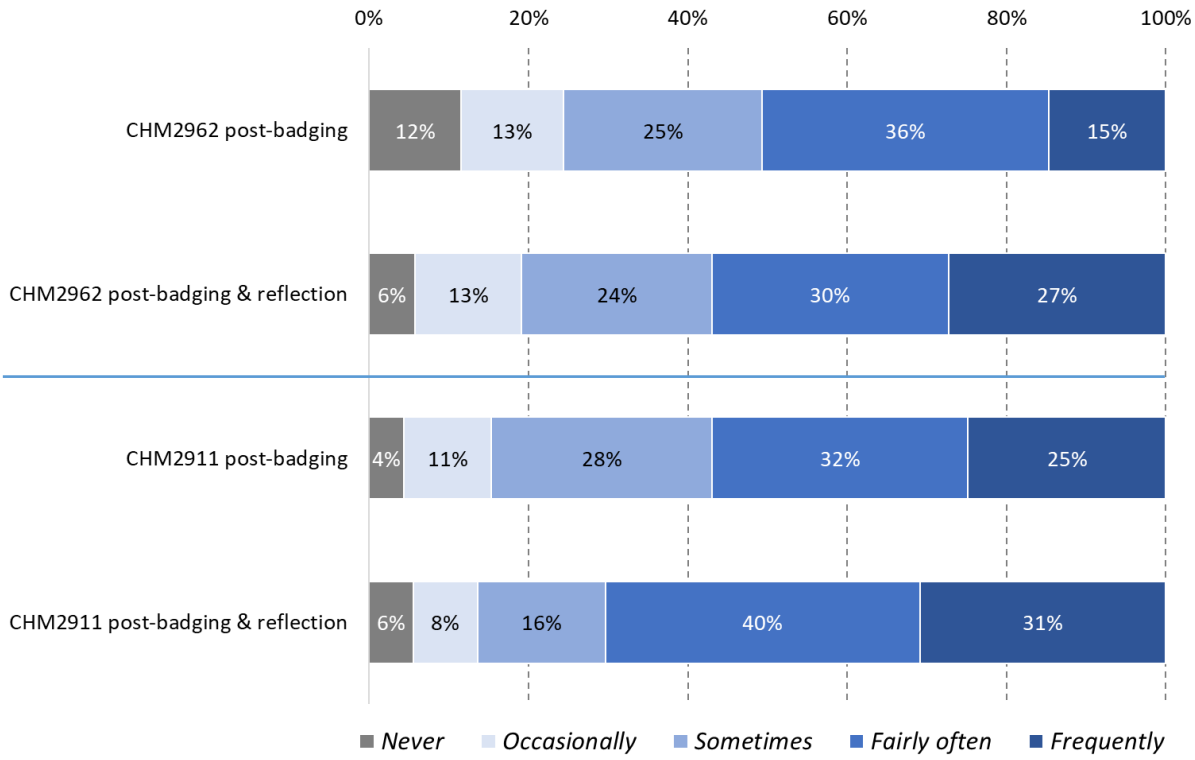

Figure 6.4 How frequently students noticed skills badges, before and after the reflective task

Note: Post-badging vs post-badging & reflection comparisons: CHM2962 p=0.015; CHM2911 p=0.063
'Post-badging' data is from Chapter 5.

Table 6.12 Student responses to statements about the impact of skills badges with and without the skills reflection task

Statement type:	***Displaying skills badges on unit materials…***	% students agreeing		% students disagreeing		Difference post reflections	
		Badges displayed (Stage 2)	Badges displayed & written reflections (Stage 3)	Badges displayed (Stage 2)	Badges displayed & written reflections (Stage 3)	Sig. level	Effect size
		CHM2962					
Positive	helped me to recognise some skills I could gain from this unit	70%	66%	9%	10%	0.77	
	prompted me to think about skills, not only the course content	60%	59%	12%	12%	0.65	
	was a positive addition to the unit	66%	53%	4%	8%	0.014	
	increased the value I saw in this unit*	55%	36%	9%	16%	0.001	0.16
Neutral	made no difference to me	37%	34%	39%	38%	0.55	
Negative	wasn't meaningful to me – I wasn't sure what they meant or why they were there	13%	16%	59%	54%	0.13	
	was unhelpful because it distracted me from the unit content / tasks*	4%	10%	78%	63%	0.001	0.16
		CHM2911					
Positive	helped me to recognise some skills I could gain from this unit	71%	81%	8%	4%	0.03	
	prompted me to think about skills, not only the course content	64%	69%	13%	6%	0.03	
	was a positive addition to the unit	64%	68%	7%	2%	0.58	
	increased the value I saw in this unit	53%	52%	13%	8%	0.91	
Neutral	made no difference to me	33%	30%	38%	47%	0.30	
Negative	wasn't meaningful to me – I wasn't sure what they meant or why they were there	20%	16%	58%	61%	0.63	
	was unhelpful because it distracted me from the unit content / tasks	5%	6%	84%	77%	0.43	

*A significant difference is noted before and after including skills reflections

Note: Data in the "badges displayed" columns is from Chapter 5.

6.1.11 The relationship between student engagement with employability and the perceived impact of the skills badges

Table 6.13 presents the correlations between students' understanding of and engagement with employability and their perceptions of the impact of displaying skills badges. There was a medium correlation for both units between 'I understand why it is important to be able to write/talk about my skills' and three positive impacts of displaying skills badges ('helped me to recognise some skills I could gain from this unit', 'prompted me to think about skills, not only the course content' and 'was a positive addition to the unit'). There was a small negative correlation between 'I understand why it is important to be able to write/talk about my skills' or 'It's important to start preparing now for a job/career' and finding the badges unhelpful and a small positive correlation between 'All that matters now is completing my degree and doing well' and finding the badges unhelpful, for both units. This could suggest that without an understanding of why it's important to be able to express their skills or some engagement with employability, some students may not be engaged with the skills badges.

Table 6.13 Spearman correlation coefficients between student employability engagement and the perceived impact of displaying skills badges, for CHM2962 and CHM2911^

Employability understanding & engagement:	Displaying skills badges on CHMXXXX materials …..						
	helped me to recognise some skills I could gain from this unit	made no difference to me	was a positive addition to the unit	prompted me to think about skills, not only the course content	wasn't meaningful to me – I wasn't sure what they meant or why they were there	was unhelpful because it distracted me from the content / tasks for the unit	increased the value I saw in this unit
It is important to start preparing now for a job/career	0.20*, 0.15	-0.04, -0.21*	0.26*, 0.09	0.28*, 0.25*	-0.08, -0.19	-0.17*, -0.27*	0.13, 0.05
I understand why it's important to be able to talk/write about my skills	0.30*, 0.36*	-0.18*, -0.22*	0.30*, 0.32*	0.39*, 0.28*	-0.19*, -0.23*	-0.23*, -0.20	0.20*, 0.19
All that matters now is completing my degree & doing well	-0.003, -0.1	0.02, 0.03	-0.03, -0.01	-0.02, -0.07	0.09, 0.25*	0.18*, 0.22*	0.04, -0.03

^The first correlation coefficient magnitude listed is for CHM2962 and the second is for CHM2911

*Correlation coefficient was statistically significant

Grey highlighting indicates at least one of the units showed a significant medium correlation and the other at least a small correlation

6.2 Themes from student focus group discussions

At the start of each focus group, students were asked what skills they felt they had an opportunity to develop in the relevant unit and their responses are summarised in Table 6.14. The most prevalent skills mentioned were (in descending order) commercial/industry/real world awareness, independent learning/independence, teamwork, laboratory techniques and equipment, communication, literature research and report writing, initiative and creativity. For CHM2911 ("Inorganic and Organic Chemistry"), time management and organisational skills and the ability to work under pressure were also mentioned, with students indicating that some of the laboratory synthesis and characterisation tasks were long and they needed to be organised and calm to complete them in the allocated time. For CHM2962 ("Food Chemistry"), analysing and interpreting data, using Excel, experiment design, critical thinking and filming and video editing (2018) were also mentioned. These skills students particularly associated with CHM2962 related to the types of tasks involved in the unit. For example, students had to design the experiments for two thirds of the CHM2962 laboratory tasks, all experiments required the collection of numeric data and many used Excel for calculations and the creation of graphs. In 2018, CHM2962 students also created a video for an assignment. It is interesting to note that thinking and problem solving were rarely or never mentioned despite their high levels of recognition (86-94% selecting 'to some extent' or 'a lot') when students were prompted with a skills list in the survey.

Table 6.14 Skills mentioned in student focus group discussions

Skill	Number of focus groups in which skill was raised	Total number of coding blocks per skill
Commercial, industry, real world application awareness	6	8
Independent learning, independence	4	8
Teamwork	4	8
Laboratory techniques and equipment	5	6
Communication, science communication	3	6
Researching information/literature	2	3
Creativity	2	2
Report/scientific writing	2	2
Initiative	2	2
Time management and organisation	1 (CHM2911)	4
Analysing & interpreting data	1 (CHM2962)	2
Use of Excel software	1 (CHM2962)	1
Critical thinking	1 (CHM2962)	1
Experiment design	1 (CHM2962)	1
Filming and video editing	1 (CHM2962)	1
Ability to work under pressure	1 (CHM2911)	1
Cleaning	1 (CHM2962)	1

When students were asked about the skills reflection task, eight major themes emerged, each with a number of sub-themes, as shown in Table 6.15.

Table 6.15 Major themes and sub-themes from student focus group discussions

Theme	Sub-themes^ (In order of frequency, with highest frequency sub-themes listed first)	Examples
Perceived purpose of employability skill reflection task	• Increasing recognition of transferable/soft skill development in preparation for employment • Developing awareness of learning and skills used and practised in the laboratory	"To bring our focus to the skills we've developed so that then we have more of a knowledge when it does come to employment prospects" "So that we actually like, consciously think about it …. Like having to write about it means you actually think about 'oh what did I actually learn? And what skills have I practised in the lab?'"
Benefits of writing skills reflections	• Increased awareness, acknowledgement, and thinking about skills • Examples that can be shared in job interviews • An easy mark	"First year Chemistry we did not have these questions, we did not think of these skills at all… Making students aware that they are using these skills, then that's just one step in the right direction" "In an employability setting it can be useful…. If I did go to an interview, I'd be like 'oh yeah, I used initiative here...'" "I saw it as an easy mark"
Negative reactions to writing skills reflections	• Felt forced, artificial; just write what's expected • Extraneous task after completing lab report; a hassle • We aren't developing 'new' skills; we already have them	"More so with that than any other aspect, you're telling them what they want to hear" "It just doesn't seem quite necessary to be honest in terms of the context of the lab that you've just done. You've done a lab, you're learning about the lab and what you're doing in that lab. " "Maybe you improve [the skills] slightly by just practicing them more. But it's not like I'm suddenly learning how to [work] with others"
Other reactions to the skills reflections task	• Writing skills reflections wasn't difficult • Duality; they're both good and bad	"It wasn't difficult" "In the initial stages you do think about it, and then once you get into the flow of writing the employability skill, we kind of all just write the same thing every week"

^Each listed sub-theme was raised in at least half of the focus group discussions (i.e. in at least 3 out of 6 focus groups)

Theme	Sub-themes^ (In order of frequency, with highest frequency sub-themes listed first)	Examples
Communication, grading and feedback on skills reflections provided by teaching staff	• Teaching staff provided no information or guidance on writing skills reflections • Confusion or uncertainty about the requirements and grading of the skills reflection task • One or two TAs provided a little information about the skills reflections	"I don't think any TAs have mentioned it" "It's hard to know how much and what is expected to write" "I felt like there was a lack of consistency with [marking] it"
Benefits of the skills badges	• Good starting point for writing reflections • Widening skill recognition and making direct link between lab task and skills needed in employment	"[The badges] were good as prompts" "Having the [badges] there kind of makes you think about there are also these other skills that we are practicing in these labs."
Other reactions to skills badges	• Having badges on every experiment limited students' thinking and/or skill recognition • Didn't notice or pay attention to the badges	"I always went to the [badges] that were indicated for that lab. Pick the one that looked the easiest" "I didn't really pay attention to them"
Suggestions for improving the skills reflection task	• Before commencing, staff provide an introduction on the skills reflection task, including purpose, instructions and expectations • TAs introduce the relevant skills at the start of each laboratory • TAs hold post-lab discussion on skills used • Keep skills badges reference page at front of laboratory manual, but don't displays badges on individual laboratories • Change how the reflections are graded	"First lab…[have] a bit of a focus on it. Like this is why we're doing it. This is what you can do. This is where the help sheet is" "Before the lab they could be like, in this lab we're trying to really improve your team working skills or your maths skills or whatever. Kind of like zoning in on that so that you know that's what you're working on" "Discussing it [after the lab], and being like "Hey, what soft skill?" If they bring it up, we'll be able to chat about it a little bit"

^Each listed sub-theme was raised in at least half of the focus group discussions (i.e. in at least 3 out of 6 focus groups)

Perceived purpose of employability skill reflection task

Students identified two main purposes for the skills reflection task: Some felt it was to help them become conscious of the skills they'd developed and what they'd learned in the laboratory, beyond chemistry knowledge. This was particularly prevalent in CHM2911 discussions.

> To make the students actually be aware of why we're doing the labs, why not everything is just theoretical. Because even though each lab has a bit of practicality in terms of applying the theory, ... you still have other reasons for doing the lab. And I think it's to make the students more aware of that and think about it maybe when they do the next lab. So think about use of teamwork or your technical skills, with machine work and stuff.

Some students felt the purpose of the task was to help them make connections between their laboratory tasks, skills developed and future employment. This was more prevalent in CHM2962 than CHM2911 discussions.

> To develop your soft skills and recognize your transferable skills, for employment... Whatever you're learning in the lab, these are the kind of soft skills that employers are going to be looking for, when you graduate.

> I think if we didn't have that section, we would have gone through the lab just doing it and then not actually thinking about how this actually would apply to us in a job scene.

A few students saw the purpose of the reflections as to prepare them for the employment process; helping them identify skill examples they could use in job interviews or develop their ability to articulate their skills to employers.

> Because we gain all these skills and, when asked, unless you've had practice articulating the skills that you've developed… [you may] not be able to articulate it to an employer… So, that's what I see the purpose is, is being able to articulate what skills you are gaining.

However, some students did not understand the purpose of the skills reflection task.

> Facilitator: So you didn't see why you were being asked to do this?
>
> Student: Not at all

Benefits of writing skills reflections

The two most common benefits of writing skills reflections were consistent with the perceived purpose. Firstly, that it increased students' awareness of skills developed in the laboratory. It prompted them to pay more attention to what they were doing, think about the skills they were using and for some, to acknowledge their personal skill capabilities. This was again more prevalent in CHM2911 focus groups.

> It definitely made me think back to the experiment, and okay, what was I doing say teamwork-wise this experiment. Or whichever skill had been highlighted in it.

> I think it's helpful … because, sometimes you're not aware about it …. you just blindly go to all the labs and you never notice what you are capable of.

Many students expressed that through writing the reflections, they identified examples they could use in job interviews. This gave them greater confidence that they have skills to offer when applying for jobs in the future.

> It is a good sort of almost bank of information…So in the future, if I have an interview, I can literally look over them all…. and think, 'Oh, I did that in the Chemistry lab. I can use that as an example'.

> It's really helpful to have an idea of. I know I'm going to have to apply for something eventually, and then you have it brought to the front of your mind when you're doing these things, so you don't get to the end and go, 'oh my god, I can't apply for anything'. You go, 'I have got some skills in there I can talk about and use'.

One student shared that they had had trouble coming up with examples of their skills in prior interviews and so they felt the reflections were important. Another student shared that they had already used one of the reflection examples in an interview and that writing about it had helped them remember it.

> I've been in interviews for jobs or internships where they ask 'name a specific time where you had to apply this specific skill'….. 'Oh there was that one lab where something went really wrong and that we were able to rectify it' and because I wrote about it, it kind of stayed in my memory.

These two benefits aligned with survey responses: Two thirds of CHM2962 and over three quarters of CHM2911 students agreed that writing skills reflections had helped them to think about skills, not only the content, identify some skills they had developed, identify some examples of skills they could use in job applications and interviews and develop their ability to express their skills in words.

A few CHM2911 students expressed that writing the reflections also assisted them with motivation, because it provided a connection between university tasks and their future; giving more purpose to what they were doing.

> Rather than like this is such a waste of time why am I doing it? It's making it …a little bit motivating; like this actually has a purpose. It's going to fit somewhere in my future. I'm not just drilling this into my head for no reason…. So I think that's really good.

Several CHM2962 students identified that the reflections had prompted them to think more broadly about employability, such as what they were going to do after their degree, or that those completing a science degree could work in a variety of jobs.

> It definitely made me think of the fact that OK, at the end of the degree I'm going to have to use the degree to get a job, so in that general sense, I guess it was useful. Because you … tend to forget. You're just doing your assignments, working from week to week... But like, this sort of gets you thinking. OK, what's the plan after finishing? What are you going to do?

> It might be helpful for students that don't want to, maybe, enter STEM-related careers. … Hey, we're still learning the same skills that other employers look for, through a science degree, ... it doesn't necessarily mean that you have to do a STEM job.

One student expressed that the information gained was helpful because it was broadly applicable across disciplines and degrees and another that the task helped them improve their reflective skills.

A number of students felt that writing the reflections was an easy way to gain a mark, as it wasn't a difficult task to complete "They were really easy to write once you actually thought about it" and "It was essentially an automatic mark on each lab report".

It is interesting that whilst in the survey 68-81% of students agreed that writing skills reflections had helped them identify skills they could improve, no students identified this as a benefit in the focus

group discussions. It appears that either the survey had prompted students and this benefit was not top of mind for the participants or it was not valued as much as the other benefits raised.

Negative reactions to writing skills reflections

For some students the skills reflection task felt 'forced' or 'artificial' and disconnected from the rest of the laboratory task, unlike when an industry context had been integrated into the laboratory background and instructions.

> It felt forced, unlike ….. say the sunscreen [experiment] or the aspirin one, where it was well integrated so you were thinking about it, without having to do this separate thing.

Some students commented that there were students who were not being genuine in their responses but simply writing what they felt would gain them the mark.

> The general feeling about that question is that it's free marks and so when it's reduced to free marks it kind of loses …. that value….They're not being genuine.

> It's definitely something like "What do they want to hear for that mark?".

A number of students felt it was an annoying extra task to do after having completed the rest of the report.

> I found it kind of, taxing, somewhat tacked on at the end. After like, writ[ing] your lab report, 'OK I'm finished my conclusion, done all that', and then it's like 'oh, here's this thing at the end'.

Another negative perception amongst some students was that the reflection task inferred they were developing new skills in each laboratory and that this was not true; "There's not variation where you would be learning new skills every week". The perception that a skill must have been significantly developed in order to reflect on it may at least partially explain why 12% or 13% of students indicated in the survey that it was not easy to identify a skill to write about, despite the skills badges displayed on the laboratory instructions.

Another negative reaction from several CHM2962 students was that the reflection task was unnecessary, because most students can already recognise their skills.

> Whilst writing about [the skills] can be helpful for some, I think most students can sort of pick up and do that without the [reflections].

A few students didn't value the transferable skills reflections because they felt that developing and recognising their technical laboratory skills would be far more beneficial for their employability.

> I feel like that [the technical skills are] what's important in terms of employability, rather than all this other stuff.

One student also mentioned that by the time they came to write up their results, they could not remember details about skill development, so they had to make something up.

> When you're in the lab, you're focusing on that lab and … the chemistry and keeping your results and so after that, when you're doing your report, whether it's a day after or a week after, often times you'll try to think back … "Well what did I actually learn as a skill in the field that I could use apart from the actual chemistry I was doing?" So a lot of times I looked at it and I was thinking "Well I can't exactly remember anything so I'll just have to make something up"

One CHM2962 student also observed that as they had a different TA each week, it was possible to copy their reflection to a subsequent week.

> I know people copied; they would copy the same thing from every lab report they did….because it was different markers.

The above negative perceptions are likely to have contributed to why 35-38% students responded in the survey that they did not like writing skills reflections. There were also more negative comments made by CHM2962 than CHM2911 students during focus groups, in line with the lower proportion of CHM2962 students agreeing that the reflection task had helped them 'to some extent' or 'a lot'.

Other reactions to the skills reflection task

Many students expressed that writing skills reflections wasn't difficult, consistent with survey responses (where only 16-23% agreed that writing skills reflection was difficult).

> They were really easy to write once you actually thought about it. You were given the prompts of what was expected to happen in that week…..[and] it was very easy to write about what you were doing because it was generally something that was pretty prominent within the lab.

Some students appreciated that the reflections were marked, because this provided an incentive to think about them and complete them.

> It's probably a good thing that it is marked. Cause like if it wasn't marked …, people would be like 'oh yeah, whatever, stuff it'. But since it's marked it makes you think about it, because you feel like 'oh yeah I gotta get that extra mark, cause who knows it might boost my grade a little bit'.

A number of students reported that the reflection task held a duality for them. Although they didn't like everything about it, they recognised it provided benefits.

> I think there's good and bad to it. I think it can be pointless and you just kind of are writing down whatever, [but] in an employability setting it can be useful.

> [It] is good that you have to think about what you did …. but it also felt forced.

> I definitely realized the value of [the reflection] questions. The thing is that you can recognize the value in something, but that doesn't necessarily mean that …..you're still happy to do it.

This 'duality' is also apparent in the survey results where although only 35-43% students indicated that they liked writing skills reflections, 67-77% of students identified benefits from doing so.

Some CHM2962 students also felt that whilst they were engaged with the task initially, they became less thoughtful over time and tended to repeat themselves.

> I think in the initial stages you do think about it, and then once you get into the flow of writing the employability skill, we kind of all just write the same thing every week….. we just get lazy.

Communication, grading and feedback on skills reflections provided by TAs

A key concern for many students was clarity about TA expectations and grading of the reflection task. Many students stated that the TAs had not talked about the task. They had not explained its purpose, mentioned what should be included or pointed out the help document on Moodle. Without an introduction, some CHM2911 students hadn't understood the purpose of the task and so hadn't thought it was of any benefit.

> Facilitator: Do you think there was any benefit to you in doing [the reflection task]?

Student: ...not until I went to a lecture [in another unit] last week… where they're like 'Hey, this is what you have to go through, you have to be able to explain these soft skills and how you implement them.'

Such observations are consistent with the low proportion of students who agreed with the survey statements "My TA explained the purpose of writing skills reflections" (29-33%) and "I knew where to find help with writing skills reflections if I needed it" (38-50%) and the observed correlation between "I understand why it's important to be able to talk/write about my skills" and student recognition of the benefits of writing skills reflections.

Where a few TAs had mentioned the reflection task, students said they simply reminded them to do it, emphasised the need to write a paragraph (not just a few sentences) or pointed out they could use the skills badges as a prompt.

> I think the one time it was mentioned, they just said… "Use those icons as a guide to help you write the reflection"

There was confusion about four aspects of the skills reflections: how much to write (a paragraph, half page or full page), what to write about, whether to write about one or multiple skills and whether to focus on one of the skills badges associated with the relevant laboratory or choose their own.

> It's sort of hard to know how much and what is expected to write. Because even though it's one mark, I might write half a page. But I just don't know how much you want.

> I wasn't sure if we were allowed to pick other [skills], or if we had to pick one of the ones for that lab. It wasn't clear.

A number of students felt there were inconsistencies between how TAs graded the reflection task and that some TAs applied additional expectations that were not evident in the instructions or gave no or unclear feedback. Since students were marked by a new TA each week, they also couldn't adjust their responses to any particular TA's expectations.

> You've identified the skill that you've learned. But then you've got to go on to how you've used it, how you've learned about it, how you demonstrated it, how you developed it, and how you can improve on it…..Well that's five different things and it might say 'or' here, but when we get marked, your TAs are expecting you to answer all of it….I felt like my TAs, on three separate occasions expected me to have demonstrated at least three of those points.

> They were also really vague with the markings. So you'd get half a mark off and they'd be like 'put more depth' … and you're like, 'I don't really know what you're looking for'.

Benefits of skills badges

The skills badges were viewed positively by many students as a useful starting point for the reflections; "It gives you a head start on what you can write in your reflection" and "I think having it at each lab is great …. in case you're lost".

Several students appreciated the badges because they helped expand their skill recognition beyond chemistry skills and the most obvious transferable skills and made a direct link between laboratory learning and the skills required in employment. Without the badges, they believed their view of their skills would have been quite limited.

> These are the kind of soft skills that employers are going to be looking for, when you graduate. So, it's good…that rather than us looking for it, … there's this little icon that helps you gain this knowledge… It's not just all about learning chemistry and the content….It was helpful definitely.

> Teamwork, communication, time management, are my top three … I reckon I wouldn't have talked about anything else without those bubbles. Cause those are just the only three things that come to mind….So I think that having the bubbles there kind of makes you think about …. these other skills that we are practicing in these labs.

Other identified benefits were that the badges gave an idea of what to expect and focus on during the experiment, drew students' attention to the skills throughout the laboratories and helped them mentally reflect on their skills.

> Sometimes if you're looking through and you're going I have no idea what this experiment is, and then you have the little bubble and it's oh OK, they expect this and this today, so maybe make sure I focus on those so then I can get through the experiment. So if it's like teamwork, you go OK I really need to rely on working with everybody else in my group.

These positive reactions to the skills badges are consistent with student responses to the survey statements "Displaying skills badges helped me to recognise some skills I could gain from the unit" (66-81% agreement), "prompted me to think about skills, not only the course content" (59-69% agreement) and they were "a positive addition to the unit" (53-68% agreement), with few students disagreeing.

Other reactions to skills badges

A number of students identified drawbacks to displaying the badges on every experiment: It made it too easy to complete the reflections, and stopped students from thinking for themselves, limiting them to just the named two or three skills.

> I basically sort of leaned on those icons, as a crutch, for the report. So it's like, 'All right, this reflection, what does it need? It needs these three icons. All right, I'll make sure I include those, and then I'm done with it', rather than actually going back and, thinking through it.

> I think along the way you just kind of get limited to the badges. If it says teamwork, then you just write about teamwork.

Some students didn't pay a lot of attention to the badges; either not noticing them, or noticing them less frequently over time; instead focusing on a subset of skills that applied across laboratories.

> I knew that they were there. I didn't really pay attention to them. Eventually I just got into the habit of just repeating the same time management skills or just the generic sort of stuff.

One student felt they wouldn't have noticed the badges without the skills reflection task.

> In the lab manual we have like the couple of skills that are used in that lab. If I didn't have to do the reflective employability skill, I wouldn't even notice that that was there in the lab manual. So it would be sort of pointless to have that there if there was no reflection.

One student felt some of the presented badges weren't relevant to the experiment they were displayed on, "I didn't particularly like it because I never felt like I developed the skills [presented]".

Suggestions for improving the skills reflection task

The most prevalent suggestion for improvement was to ensure that there was a clear introduction to the skills reflection task at the start of semester, including its purpose, benefits, instructions and expectations.

> [At] our first lab or at one of our lectures, … you should discuss the importance of these employability skills and why we're looking at them….and explain how to answer the question. Because to date I'm still lost.

> The instructions need to be clearer, that you don't have to reflect on one of those couple [of skills] that are highlighted. You can pick your own, whatever you felt was relevant to you.

A number of students suggested TAs should briefly mention the target skills at the beginning of each laboratory ("maybe just have the little bubbles on the starting slides") and how they are important in the experiment. This would provide an overt link to the skills, encourage students to think about them during the session and integrate the skills into the laboratory, instead of them being an 'add on' at the end of the proforma.

> The demonstrators need to [say] just a few words about it, so to kind of bring it to your mind at the start of the lab, just so you kind of think about it. And I reckon that would make writing it more important, and also probably easier. Cause you'd be like oh I've been thinking about this the entire time, I'm really conscious of what I've been doing.

Some students suggested having a short post-lab discussion about skills, to enable them to think about what happened during the laboratory and identify ideas for reflection. This would help students more genuinely engage with the reflection ("to put some thought into it"), rather than being focused only on the mark.

> At the end of each lab you might have [a] discussion with your TA… The fact that you've got other peers around you [that] you can build off and because it's fresh, you've just finished the lab, you remember what happened…..

Some students proposed that the badges be applied on each laboratory for an initial semester, and then removed from later experiments, whilst retaining the badge summary page for reference.

> I think it's a good thing to have at the very start when it's first introduced to students… but maybe we don't need those badges for next semester but still have the discussions…

> Don't have it in front of every experiment but have it just as a page at the front of the book….

A number of students proposed different ways of grading the reflections, such as awarding a 'bonus' mark or not marking it. However, some thought a bonus mark was really no different (because all students would want the mark, "so, everyone's gonna do it then") and that students wouldn't write the reflections if they weren't marked. One student suggested allocating more marks to the reflection, so students apply more effort.

> I think just like delegating more marks to it. Because since it was just one mark, in a report I sort of correlate the amount of marks to how much to write and what to include, and just one mark sounds like, 'Oh yeah, just a couple of sentences. Right.'

Several CHM2962 students suggested asking students to reflect using the STAR format so the reflections would be immediately relevant for job interviews ("that might be more useful") and so students have a specific framework to guide them in writing their reflection.

> In interviews when they ask you questions you're supposed to answer in a certain format, like the STAR format …. We could probably apply that.. for the reflection as well… just so they have a format to follow.

Similarly, one student suggested providing more explicit prompt points for writing the reflection:

> Maybe have a more concrete criteria so people knew what points to put ….So one point would be list the specific skill. The other point is how it applies to maybe a specific employer…..And a third could be how was that skill specifically used in the lab? Or little things like that.

Suggestions were made about the timing and frequency of the skills reflection task. One student was concerned that if the reflections were only incorporated into second year, he would probably forget them, "If units down the track don't do it as well, then they might sink in to like the depth of my mind where I don't bring them out". Students suggested it should be incorporated into some third year units but less frequently (every second week, three times a semester or following projects or multi-week laboratories). This would retain the benefits without it being "too much". Other students proposed that it be introduced in second semester of first year (so students are not overwhelmed during their first semester) and continued throughout the degree.

> I think if you could bring it in first year, cause it seems like a more introduction to uni thing like, 'we are looking at your career skills; that is what we're trying to build here'. So I think that would be a really good introduction to it, and then you just carry it through the rest of your degree.

Several students preferred more direct links to employment such as how laboratory methods are used in an industry setting or guests giving a lecture or workshop in which they explain the how the transferable skills are important in their industry context.

> And then having whether it be a guest lecturer or something come … and provide some context. It's like, hey, we actually really look for people that can work in teams in our lab or in whatever context.

Other suggestions included asking students to reflect on a variety of tasks (not just laboratories); using different skills badges each week so students are more likely to reflect on different skills; incorporating skills recognition and articulation into a compulsory science unit; having TAs 'mark off' students as having effectively used specific skills in each laboratory and incorporating skills reflection into a post-lab task before students leave the laboratory, to promote authenticity and capture their experiences before they are forgotten.

6.3 Themes from TA focus group discussions

Each TA focus group commenced by asking TAs what skills they believed students had the opportunity to develop during the relevant unit. The most prevalent skills mentioned by TAs were independence in the laboratory, technical/laboratory skills, commercial awareness, organisational and communication skills. Individual TAs also mentioned understanding which techniques to use and why (rather than 'blindly' following the manual), asking more questions to gain deeper understanding of what they were doing, teamwork and how to deal with real 'unsanitised' data from students' own compounds ("[it's] their first exposure to non-ideal data"). Whilst students raised teamwork more often and they mentioned a few more skills than TAs (possibly because they thought across the whole unit, whilst TAs focused on the laboratory component), the skills identified by students and TAs were broadly in agreement.

The themes that emerged from TA transcripts about the skills reflection task are summarised in Table 6.16 and described in more detail below.

Table 6.16 Major themes from TA focus group discussions

Theme	**Examples**
TA and student understanding of the reflection task purpose	”Students don't know how to reflect on their skills in their work, right? They're just doing things, they don't really think about the impact of it, and that's sort of what we're trying to teach them” “So that they actually think about it and then can articulate it in the future” “I think they're understanding that the course is meant to be, is to develop their skills to directly get them a job”
Quality of students’ reflections	”They were quite variable. I think the majority of them were in the middle; they weren't very good, most of them weren't very bad” “I was most surprised that they all took it seriously and they wrote like a proper paragraph. You know, even the ones that would leave blanks in their report would have pretty okay reflective pieces”
Guidance provided by TAs to students	“I was like, ‘Oh, don't write about technical skills. Write about the skills that [you] notice on the badges. Like write the reflection based on that’” “I didn't direct the students to [the help sheet]”
TA marking approach and confidence	“I only gave one mark if they mention how they're going to use it in the future” “I felt they were OK to mark. The training that we got on how to mark that was good”
Impact of the reflection task on students and TAs	“I think just the awareness that they can actually translate that into interviews later on” “In the end, I really liked, I really enjoyed and felt satisfaction reading a lot of them” “I was slightly just disappointed that they didn't read the instructions how to do that section”
Drawbacks of the reflection task	“I think it's a good idea. I just wonder if they were engaged enough with it, or if it was just a little extra thing that they had to do. Like a formality” “If somebody wrote a really good one, they got a one out of one for it, they could just copy it and write it again for every prac. And I can bet there were some people who did do that”
Skills badges’ benefits and drawbacks	“I think they're a good jumping off point for people, especially at the start, where they're a bit unfamiliar with what they are meant to be doing there” “I feel like if you assign [skills badges] to a specific experiment, they will just like, okay, this is the answer”
Suggested improvements to the reflection task	“Make the link on Moodle to how to write [about] employability skills maybe more obvious, talk about it more”. “I really think if you got every demonstrator to say something at the very first class, at the end or the start or both, about what it is, and even like why they're doing it” “I think because it's not weighted enough; maybe it should be worth two marks or something, right? Then maybe they'd put more effort into it”

Perceived purpose of the employability skill reflection task and student understanding of the purpose

Some TAs believed that the purpose of the employability skill reflection task was to help students think about their learning and what they're doing ("[to] think about what they've actually done….what did I actually learn today?") and how it's useful beyond the specific laboratory task of focus.

> I guess if you didn't have that, they'd just focus on the prac again, like the compound or a number, and I guess they don't think about the steps that it took to get there. I guess it helps for them to look back.

Two TAs saw the task as trying to help students prepare for the job application process, by helping students recognise they are developing workforce-relevant skills within the laboratory program and that they can articulate these examples during job interviews.

> I think it's just to make them like, I don't think they are aware that they are developing all these skills in labs as well. … they don't realize that that they are actually developing all those skills in the course itself. So it's just to make them aware of that so that they would know how to translate it into maybe like an interview later on.

Several TAs felt some students recognised the purpose of the task, especially those who had completed some reflection on their learning in first year chemistry laboratories, but they felt not all students understood the purpose.

> Definitely some of them didn't…Because even at the end of their semester, [when] they should have figured out what we wanted from them in that section, then they still weren't really thinking about it and not answering it properly. You know, they were still talking about technical skills rather than actual skills.

Quality of students' reflections

As indicated in the previous quote, TAs felt some student reflections were not of high quality and the quality of the reflections was variable.

> TA1: Maybe it's like a 50/50 split of people who just didn't get it.
>
> TA2: Yeah, some students give really nice paragraphs, really nicely fleshed out things. Some students give a couple of sentences.

The types of problems TAs identified in some reflections were students focusing on technical skills rather than broader transferable skills or students describing the skill generically or how they carried out the skill, rather than personally reflecting.

> They don't really apply it back to themselves at all. They just give a general overview of the skill.... It's a personal reflection, they need to be a bit more personal with it. Which is my comment like, "You need to reflect on yourself, you can't just tell me what the skill is".
>
> Or you can't be like, "Numeracy" and stuff, and then just go through the calculations that you did in the lab….That's not [a reflection]…which is often what would happen.

One CHM2911 TA didn't feel that the overall quality of the reflections changed over time ("what was really disappointing is that I didn't see much improvement throughout the term"), but some CHM2962 TAs felt that the reflections did improve during the semester such that by the end, most students were writing a 'good' reflection ("In the beginning it was I'd say about 40% was good, and

towards the end it was over 80%”). Student survey responses were consistent with the latter observation, with 70-75% indicating “Writing skills reflections got easier as I did more of them”.

Guidance provided by TAs to students

Most TAs involved in the focus groups indicated they gave students little or no guidance or information about writing the reflections unless the students asked “No, I didn't. Not really. Only if they asked me about it, really” and that they hadn’t talked to students about the purpose of the task.

Only a few TAs from the focus groups said they had raised the reflection task with students. One had added a slide in his end of laboratory summary, reminding students that they needed to complete the skills reflection and sharing two reflection examples from the TA notes.

> I have it at the end of my slides ….."Here's what we're expecting for it. Here's the page to refer to." And then I put up the bad example and the good example for it.

Another TA said they emphasised to students not to write about technical skills.

> Oh, don't write about technical skills. Write about the skills that [you] notice on the badges. Like write the reflection based on that.

None of the CHM2911 TAs drew students’ attention to the help document on Moodle about writing the skills reflections (“I didn't direct the students to [it]”) and some of them seemed unaware of it although they thought it might exist (“I didn't see it but I assumed there would be one”). Some of the TAs who had taught in first year were aware, however, that there was a general description of how to write a ‘reflective discussion’ in the chemistry student laboratory handbook but that not all students had read it (“It's like they've never read the handbook on how to write a reflective discussion”).

One CHM2962 TA said he had mentioned the skills reflection help document to students and that he thought it was beneficial to students.

> I mentioned it at the end of every prac, when I was telling them how to write the report, what they should be thinking about. I mentioned, "You've got the actual document on Moodle" …. but ... some still didn't look at it. I think the ones that looked at it, at least once in a semester, did well after they looked at it.

Consistent with these findings, student survey statements on “I knew where to find help with writing skills reflections if I needed it” achieved only 38% to 50% agreement and “My TA explained the purpose of writing skills reflections” achieved only 28% to 33% agreement from students.

Marking approach and confidence

A number of TAs indicated that students did not get the full mark for the skills reflection task if they wrote mostly or only about technical skills or showed little evidence of reflection.

> TA: I gave a lot of 0.5s
>
> Facilitator: What do you think was missing? …. why weren't you giving a whole mark?
>
> TA: There was a tiny bit of reflection, but mostly technical stuff

One TA indicated they had used an additional criterion in their marking (even though this was not required in the task description).

TA: I gave a lot of 0.5 marks, even though they've mentioned those [transferable] skills ... So I only gave one mark if they mention how they're going to use it in the future. So, if they don't mention about the future, how they're going to use it,… I gave 0.5.

Facilitator: Did you tell them you were going to do that?

TA: No. No I didn't.

This supports the claim made by a few students in the focus groups that some TAs had applied additional criteria without prior explanation.

TAs indicated they accepted any transferable skills students chose to reflect on, regardless of which skills badges had been displayed on the laboratory, as long as it made sense.

> As long as it's valid, but yeah because it's, you know, it's personal, if that's what you feel that you achieved that week, then … good for you.

The TAs also indicated they were comfortable marking the question and felt training they had received about marking students' reflections (either in the general TA induction or in the specific CHM2962 induction component on the skills reflection question) had been helpful.

> Yeah, it's good. I mean I think the TA induction sort of showed us what's good and what's bad and examples and sort of got the gist of it.

Impact of the reflection task on students and TAs

Some TAs said they were unaware if the skills reflection task had benefited students because students didn't talk about it "They didn't mention it but they didn't complain about it either". However, a few TAs felt students had benefited in terms of recognising examples for job interviews, why some of the CHM2962 laboratory tasks were more open-ended or identifying personal weaknesses and how they could improve in the future.

> There was an added benefit…. particularly towards the end of the semester, a lot of the students actually started recognizing why we leave the gaps in the lab manual in the prac, for them to fill …. And I don't think they would have thought about why we're making it harder for them, if they didn't have to reflect on it.

> They were picking up their own weaknesses and they're like, 'Oh, actually maybe for the next lab I should prepare a bit more, or I should plan it out a bit better. Or … there are things I can do to manage my time better'. And I felt that gave a huge extra benefit for those students who actually noticed those things.

These observations are supported by student responses to the survey statements "Writing skills helped me make more sense of my experiences" (61-72% agreement) and "Writing skills reflections helped me identify some skills I could improve" (68-81% agreement).

One TA agreed with some students that the reflection task was an 'easy mark'. "It's a pretty easy mark, though. The easiest mark, maybe, in the report".

In terms of the impact on the TAs, some felt frustrated or disappointed when students didn't complete the task to a good standard.

> It is frustrating that they had done [some reflection] in first year. I was like, "Oh this isn't totally new to them", right? It is something they had looked at before. That's why it can be a bit frustrating when they just don't get it completely right, I guess.

Other TAs expressed pleasure, enjoyment or satisfaction when students indicated they had listened to the TA or benefited from their instruction ("It felt nice"), identified opportunities to improve or when students made a link between the laboratory activity and their future.

> In the end, I really liked, I really enjoyed and felt satisfaction reading a lot of them, because …. they really identified what they did wrong in terms of their attitude and their general demeanour and the skills that they were lacking.

Drawbacks of the reflection task

Three drawbacks of the skills reflection task were identified by TAs, which were also mentioned by students in focus groups: a lack of understanding of, or engagement with, the task by some students; the fact that because a different TA marked each pro forma, students could potentially re-submit a completed successful reflection in a subsequent pro forma and that the task was less immediately relevant than the laboratories that were contextualised to an industrial application.

> A lot of the pracs themselves have changed to have more of a focus on real world applications, which I really like, and I think the students like that too. And [they] benefit from that potentially more than a one mark question at the end that would ask them to reflect about skills.

Skills badges' benefits and drawbacks

Skills badges were seen by TAs to offer both advantages and disadvantages. TAs raised many of the benefits mentioned by students, namely that they provided a useful starting point for students in writing their skills reflections, promoted skill recognition related to each laboratory ("you want them to see that those are the things we expect [them] to develop in the labs"), provided a visual prompt for skills ("they're just easy to kind of notice") and sometimes were a useful indicator of the requirements of the practical (such as teamwork).

However, a number of TAs mentioned that many students tended to write only about the badged skills and so they may be limiting students' broader skill recognition or reflection and preventing students from thinking for themselves about what skills they have used or developed. Students also raised this issue in focus groups.

One TA commented, though, that removing the badges from all individual laboratories may result in some students reflecting on the same skill for each laboratory such as teamwork or communication;

> I think they'll get very 'same-y' once we do that because they'll ….just keep writing about teamwork, because it's an obvious one.

Suggested improvements

TAs discussed a number of ways to improve the skills reflection task. As requested by students, many TAs felt that communication about the task should be improved; the 'help' document for writing reflections should be better promoted to students and teaching staff should introduce the task at the start of the semester and explain its purpose. Several TAs echoed the student comment that because the task was only worth one mark, some students didn't put much effort into it and that making it worth two marks might cause students to think about it more carefully. However, another TA cautioned that it was important to not provide too many 'easy marks' to students in the laboratory tasks:

> I already think that a lot of marks in these reports are sort of given to them; like there were a lot of very easy marks in some of the reports, and I would be careful about sort of extending that.

No specific training had been provided to CHM2911 TAs about the skills reflection task and some felt this should be added and include key points on the purpose of the task, how to go about it and marking criteria.

> Even just an intro at the start saying, "Okay," just a little presentation for 10 minutes sort of just tell us some key points to focus on.

Following such training, the TAs said they would confidently communicate this information to students ("because without that, I'm just sort of left to my own").

A few TAs also proposed changing the skills reflection task wording in the pro forma to explicitly link it to job applications, to help students understand the task purpose ("We could put in a line that says, think about when you are in a job interview or something, in the pro forma"). Extending this, one TA suggested asking students to answer a job interview style question on some pro formas: "What if you re-phrased the question as if you got asked this question at a job interview?" (similar to a student suggestion), and perhaps varying the specific question students were asked in different laboratories.

Another suggestion included keeping the skills badge summary page, but taking the badges off individual laboratories, identical to a suggestion made by a number of students:

> I feel like the badges should be there, but not like a specific badge for a specific experiment kind of thing…. so maybe like just a general one and then they get to choose what they want to write about.

One TA proposed not including a reflection in every laboratory but changing it to an online task three or four times a semester. Each reflection could then be about several laboratories and at the end of semester students could reflect on their improvement. Such reflections could be attributed more than one mark, with the reflection grade separated from individual laboratories, similar to the separate reflective task included for student research projects.

Student 1	Is there a way that you could potentially take it out of every lab report …. but then maybe every few weeks they have an online assessment that's a reflective discussion on their last two or three labs, and then that is marked?
Student 2	At the start of semester, end of semester, they can reflect on how much they've improved, what they think, that sort of thing..… For the research project unit, they have 10 marks … just a paragraph or page they write about the project. So, it's been done. It works.

7 Discussion

In this chapter, the findings from the four elements of the project are drawn together and discussed in terms of the two key research questions:

- Do science undergraduates at Monash University and the University of Warwick recognise they are developing transferable skills during their degree and value such skills?
- Does engaging science students in reflection on their degree experiences and/or displaying skills badges on curriculum materials increase students' ability to recognise and articulate their transferable skill development?

Other impacts of the interventions and factors that may influence the effects of skills reflection and displaying skills badges will also be discussed.

7.1 Recognition of skill development and value by science undergraduates

Undergraduates taking part in this study identified an average of three or four skills as developed during their degree. Most students named a subset of teamwork, thinking and problem solving, time management, laboratory/practical and communication skills, with a third to half of students naming each of these skills individually. A fifth to a quarter of students named organisational skills and a few identified independent learning or study skills, the latter particularly at first year. It is a positive outcome that a reasonable proportion of students are able to recognise the development of these skills during their degree, as laboratory/practical skills are desired by most science employers and the other recognised transferable skills are desired by most employers in any field or sector (Deloitte Access Economics, 2014; Lowden et al., 2011; Purcell et al., 2008; QS Intelligence Unit & Institute of Student Employers, 2019; The Foundation for Young Australians, 2016; Wakeham, 2016).

The skills students were most interested in further building were the same as those identified as developed, with the exception of teamwork (namely communication, laboratory/practical, thinking and problem solving and time management), as well as skills related to finding employment (such as job application and interview skills, career knowledge, business acumen and work-related experience). A high proportion of Warwick students were interested in further development of their communication skills, especially presentation skills. Third year students at both Warwick and Monash universities appeared satisfied with their discipline knowledge. Monash third year students were satisfied with their teamwork skills. However, some third year Warwick students desired further development of their teamwork and leadership skills.

On average, students identified three skills as sought by employers, with teamwork, communication and thinking and problem-solving skills the most commonly named. Once again, it is pleasing that a reasonable number of students recognise that employers desire these skills (Deloitte Access Economics, 2014; Sarkar et al., 2016; The Foundation for Young Australians, 2016).

Students' views of skill development were very narrow with only a few students recognising development of skills such as numeracy, including data analysis, independent learning, commercial or business awareness, flexibility and adaptability, leadership, interpersonal, research, computer/IT, initiative, creativity and innovation. Students also did not recognise that these skills are desirable to employers (Lowden et al., 2011; QS Intelligence Unit & Institute of Student Employers, 2019; Sarkar et al., 2016; World Economic Forum, 2018). There is a need to draw students' attention to the value of these specific skills and provide opportunities within the curriculum to develop them.

A reasonable proportion of students recognised some skills highlighted by their universities or departments as graduate attributes (Monash) or module aims and learning outcomes (Warwick), namely thinking, problem solving, communication, teamwork and laboratory skills. However, Monash students did not recognise or desire development of other stated graduate attributes (cultural competence, ethics, creativity and innovation) and Warwick students did not recognise or desire development of stated learning outcomes such as numeracy, data analysis, experiment design and software/IT skills. It appeared that identifying skills as graduate attributes or learning outcomes was insufficient for students to recognise their development in the curriculum or their value in employment. This is in agreement with a recent study by Jorre de St Jorre and Oliver (2018) wherein students found 'graduate learning outcomes too generic to be meaningful' and that such skills were likely to be better valued and recognised when contextualised and assessed and when development opportunities are implemented with clear communication to students. Whilst this study did not aim to analyse which skills were assessed across each degree, some observations can be made regarding assessment and skill recognition by students involved in this study. For example, at Warwick, data analysis and numeracy skills were assessed in numerous chemistry units but students did not recognise development of these skills. At both Warwick and Monash, there was no explicit grading of the quality of students' teamwork skills in the chemistry curriculum at the time this research was undertaken. However, students did recognise development of this skill. The latter observation also applies to time management skills. There was assessment of written communication in both university's chemistry curricula and students did recognise development of this skill. Whether the assessment contributed to that recognition is unknown.

Academics' views of transferable skill development and assessment in science degrees at Monash and Warwick were studied by Sarkar et al. (2019) and provide additional insight into a possible relationship between assessment and skill recognition by science students at these two institutions. In the study by Sarkar et al, academics reported that 60% of units both developed and assessed numeracy skills. However, results from this study indicate that students do not readily recognise the development of this skill. By contrast, 60% of academics in the Sarkar study believed their units developed teamwork with only 29% of academics believing they assessed this skill. Nevertheless, students in this study had little difficulty in recognising development of their teamwork skills. A similar observation applied to time management and organisational skills in the Sarkar study (academics believed 72% of units incorporated this skill, 32% assessed it) with once again a reasonable proportion of students in this study recognising this skill as developed. Whilst this is not a thorough evaluation of the relationship between assessment and skill recognition, these findings suggest that assessment of a skill does not automatically result in student recognition of it and that skill assessment is not an essential criterion for recognition of teamwork, time management or organisation skills. Assessment tasks involving some skills (such as data analysis and numeracy) may require explicit highlighting of the relevant skills to ensure student recognition of them.

Matthews and Hodgson (2012) reported significantly lower recognition of development of quantitative skills in a biomedical science degree in comparison to scientific knowledge, writing, communication and teamwork skills (based on a quantitative survey using a skills list), supporting the idea that students may struggle to recognise the development of this skill more than some others. It is possible that for science students not taking a mathematics major, their primary focus is on discipline knowledge and skill development, and numeracy development is a 'background' effect of which they are not conscious. The findings from Matthews and Hodgson and those from this study add support to the assertion from Oliver and Jorre de St Jorre (2018) that all skill development opportunities, even those assessed, were more likely to be recognised and valued when they were clearly communicated to students. Likewise, Kinash et al. (2018) in their study on the link between

assessment and graduate employability concluded that whilst academics often intentionally design assessment tasks to enhance graduate employability, students do not readily connect the two. They state "If educators are not articulating the relevance of assessment to graduate employability, then students are less likely to make the connection". They also concluded that students were highly interested in developing their employability but did not recognise that assessment tasks were an important pathway for doing so. They recommended that academics undertake "explicit articulation on the links between assessment, graduate employability and career identity".

It is important to note that some skills may not be recognised by many students because there are few opportunities to develop them in the curriculum. In the Sarkar et al. (2019) study, a minority of science academics felt that they were incorporating leadership, flexibility or adaptability or commercial awareness in their units and very few believed they assessed these skills.

Findings from the voluntary skills reflection program in this study added further insights into students' ability to recognise that transferable skills improved within their degree. Whilst students were provided with a list of nine skills, they predominantly reflected on teamwork, planning and organisation, communication, problem solving and use of tools, technology and software; the same five skills most commonly identified by students in the skills survey. Very few students reflected on professionalism, creativity and innovation, initiative and intercultural competence. This supports the conclusion from the skills survey that science students were either not provided with sufficient opportunities to develop these skills in the curriculum or did not recognise them. Students seemed much more likely to recognise skills that involved a readily identified and essential tangible element in the form of another person(s) (teammate(s) or audience), time, a problem, or a tool such as laboratory equipment or a specific software package. More abstract skills such as creativity, initiative or professionalism that are not 'flagged' by an obvious tangible element, appear unlikely to be identified.

There appear to be few other studies to date involving the investigation of science undergraduates' perceptions of their development of professionalism, creativity, innovation, initiative or intercultural competence. In the Sarkar et al. (2019) study, half of the surveyed science academics thought they were incorporating the use of initiative in their unit, with 28% of the opinion they were assessing it, although whether they were assessing it directly or 'by proxy' was not clarified. However, the results of this study suggest that science students studying chemistry are failing to recognise development of initiative through their degree. The Sarkar et al. (2019) study did not investigate academics' beliefs about the incorporation of professionalism, creativity, innovation or intercultural competence. Research by Ibo (2014) amongst chemistry undergraduates and staff indicated that professionalism was perceived to be significantly less important for students to develop during their degree than scientific analysis, problem solving and communication skills. A lack of priority around development of professionalism during a science degree by both staff and students may contribute to a lack of unprompted recognition of it. However, students in this study also indicated that they lacked understanding about what professionalism meant and how it could be demonstrated. Such a lack of understanding would interfere with students' ability to recognise they had developed professionalism during their degree.

Students in the voluntary reflection program could readily identify when they had developed or used teamwork and communication but found it difficult to identify situations in which they had developed other skills. As one student shared:

> Teamwork and communication were very like easy skills to write about. Like, every time I thought of a skill that I improved on, I thought, oh, this is communication or this is clearly

> teamwork. But the other skills are more difficult to identify. Like I couldn't think of any situations where I developed much on those other skills.

Consistent with this observation, teamwork and communication were raised most often in focus group discussions, with use of tools and technology and organisational skills raised the next most frequently. Problem solving, data analysis, initiative, leadership, critical thinking, researching information, experimental design and industry awareness were mentioned only occasionally. Students seem to require prompting or signposting to recognise or recall examples of the development of these latter skills. Students also found it difficult to recognise or articulate cumulative skill development. These findings confirm the lack of awareness of development of a number of important employability skills. They also highlight an inconsistency with the recognition of thinking and problem-solving skills. Students readily name thinking and problem-solving skills as being developed during their degree, but find it difficult to recall and articulate specific examples of the use of these cognitive skills.

Students stated that a prompt list of skills in the reflection program was useful. However, it was insufficient to help students identify examples of the development of some skills (professionalism, initiative, creativity and innovation). These findings suggest that it may be necessary to signpost skills explicitly in the curriculum to help the majority of students to recognise their development and importance in employment. Such findings are consistent with other research such as a Danish study of recent physics graduates who struggled to identify the skills and competencies they had gained from their degree and relate them to potential jobs (Nielsen & Holmegaard, 2016) and a UK review which concluded STEM graduates suffer from a lack of awareness of employment-relevant skills they have developed during their degree (Wakeham, 2016).

Students identified group projects, assignments, presentations and laboratory or practical activities as the main contexts in which skills were developed in the curriculum, followed by tutorial discussion or problem solving activities and data analysis, coding or statistics tasks. Individual assignments and lectures were rarely associated with skill development unless quizzes were incorporated. Students saw a variety of tasks as important for providing a breadth of skill development opportunities and that repeating the same type of tasks (which they believe is common in the curriculum) will not develop any new skills. Students also believed that they developed more skills when tasks were open-ended, when they had to think for themselves and when they interacted or communicated with others, compared with when tasks were closed, highly directed or completed independently.

> [In] a lot of labs, the method's pretty set and you know if you're careful with your work you're not going to have any mistakes. And so at the end of it I don't feel like I've used as many skills.
>
> Mainly when you're interacting with other people do you develop, I think, most of the skills
>
> Facilitator: What kinds of situations caused you to develop these skills?
> Student**:** Usually facing problems. So when I had like a problem in a team work project that we were doing … or if I had a problem with a practical or that kind of thing, I just noticed I had to come up with ways to resolve these issues and that led to skills.

These findings suggest that it is important to provide a breadth of activities and assessments in the curriculum, including sufficient interactive tasks and open-ended problem solving, decision making, research or other tasks, to help students develop the range of transferable skills they will require in the workforce. Many prior studies have emphasised that open-ended problem-based learning (PBL) and research projects help STEM students develop a wide range of employability skills, including oral and written communication, teamwork, independent learning, initiative, information research,

interpersonal, critical thinking, problem solving, creativity, data analysis, organisation, time management and project management skills (Aziz, Zain, Samsudin, & Saleh, 2014; Ghee, Keels, Collins, Neal-Spence, & Baker, 2016; Howitt & Wilson, 2016; Kolber, 2011; O'Sullivan & Cochrane, 2009; Pierrakos, Zilberberg, & Anderson, 2010; Tarhan & Ayyıldız, 2015; Wang, 2016). It is also important to provide means for students to recognise they have developed a breadth of skills in these tasks, through explicitly raising or sign-posting them, or involving students in reflecting on their skill development during such projects (Dunlap, 2005; Howitt & Wilson, 2016).

Students involved in the skills reflection and badging research indicated that they easily recognised opportunities for teamwork development in the curriculum through laboratory tasks, group assignments and presentations. The development of teamwork is valued by students because they know it is a skill required in the workplace, a conclusion also found in other studies (Matthews, Hodgson, & Varsavsky, 2013; Wilson, Ho, & Brookes, 2017).

> It makes more sense to have a team with you because that's sort of how you need to work in the real world, that's how you work at a job.

However, students broadly felt they are being provided with an appropriate number of tasks that develop teamwork and do not desire more of them. These findings suggest that it is important to highlight to students other skills that can be developed though team tasks, as students seem to be recognising only development of teamwork and perhaps communication skills from such tasks. Other skills that they are likely to develop from team tasks include problem solving, negotiation, conflict resolution, leadership, decision making, self-management, accountability, time management, planning and organisation (Watson, 2002; Wilson et al., 2017). Research by Wilson et al. (2017) suggests that, when prompted by a list, science students can recognise the development of additional skills such as these in team tasks. However, their research also suggests that how team tasks are constructed and implemented can have a significant impact on the benefits obtained from them, with more value obtained when a cooperative element is involved (rather than the task being broken into smaller elements that are then completed by individuals), class time is allocated to work on the team task and groups are small (fewer than four students). It is also possible that if the range and value of skills students stand to gain from a teamwork task are clearly communicated to them, they may feel less frustrated when some students do not contribute fairly to the task.

Overall, findings from this study indicate that undergraduates are unlikely to recognise most transferable skill development opportunities in the curriculum (aside from teamwork, communication and laboratory skills) unless they are explicitly pointed out to them. Students also do not appreciate the breadth of skills employers are seeking from graduates. It is very important to design learning activities that offer students opportunities to develop a wide range of skills and to explicitly highlight to students the skills associated with such activities and their importance in employment.

7.2 The impact of reflection on students' ability to recognise and articulate transferable skill development

In the voluntary skills reflection program, writing reflections on curriculum-related skill development was associated with an uplift in self-rating of the skills that were reflected on (communication, problem solving, teamwork and use of tools and technology). This suggests that reflecting on skill development experiences may assist students to recognise skills they have developed during their degree.

Findings from the reflection program indicated that reflecting on skill development can increase students' confidence in their ability to articulate their skills and present themselves effectively in job interviews and applications. Reflecting on degree-related skill experiences enabled most students to identify examples they could use in the job application process.

> I definitely think it's been effective… before I actually go for a job interview I'm going to get the PDF … with like the skills that I've learned and kind of practiced, and so if someone asks me a question, I've got the answer right there.

> It's valuable to write the skills down, and reflect on them, because then you can talk about them in the interview and you have like this whole range.

Similar benefits were also identified by volunteer undergraduates when they reflected on extracurricular activities and part-time work experience (Reid, 2015; Rowland et al., 2019), suggesting that reflection can be used by students to enhance confidence in and articulation of employability skills when applied to either curricular or extra-curricular experiences.

Engaging students in reflection on in-curriculum skill development experiences also helped students in other ways: many students saw more value in curriculum tasks because for the first time they recognised skill development as the purpose of such tasks.

> I found that I was realizing why we were doing some of the things in classes; like some of the activities I thought at the time were pointless. But as I sort of did reflection on what we did and what the outcomes were and stuff,… I realised a lot of the activities we did in class did have a point to it.

This recognition led to increased motivation to complete tasks and increased satisfaction and feelings of productivity for some students.

Participating in skills reflection significantly increased the proportion of students who believed the skills they were developing at university were relevant to employers. At the start of the program, only just over half of students believed the skills developed at university were employer relevant, consistent with the percentage (53%) identified in a multi-university, multi-faculty study by Bennett et al. (2015). This increased to 80% at the end of the semester of reflection. Some students also became more engaged with career management behaviours. They became more motivated to seek out new opportunities to address skill weaknesses or gaps and prepare for employment or to take more action during classes to further develop skills.

> The program kind of made me go out and sign up for things that I would've just ignored last time; and thought oh I'll do it when I'm in my final year or something …So instead of sitting at home, I will go to the industry night instead and talk to potential employers or like sign up for volunteer things that might be beneficial to develop some new skills and stuff. So I think it's a bit of a motivator to go do things….. It just kind of made you like more aware; like constantly thinking about the future.

> I was looking for ways that I could actually work on those skills. So [another student] and I like organised a meeting between two societies to organise a trivia night and so that's I feel like working on initiative and leadership. … I would probably say it inspired me to look for new opportunities to develop skills

The latter finding suggests that engaging students in reflecting on employability skill development may prompt some to start thinking about career management and take action on it, as called for by Bridgstock (2009) and Clarke (2018), in their models and discussions of graduate employability.

Students needed time and multiple opportunities to develop the ability to recognise their skill development and articulate it, and expressed a desire to reflect on their progress over time and across units, with marks allocated to assist with motivation. Introducing reflective tasks early in a semester would be advantageous, as students found it easier to engage in reflection in the first half of the semester, when their time and attention was not dominated by summative assessments and cognitive load was lower.

The in-curriculum reflection part of the study provided students with multiple opportunities to reflect, with a small proportion of marks awarded to each reflection. Students were provided with supporting information and the skills badges provided a list of possible skills on which students could reflect. Pre- and post-survey data indicated that writing skills reflections on laboratory tasks may enhance the recognition of development of some skills beyond that from displaying badges alone. Survey responses indicated that the reflective task helped two thirds to three quarters of students develop the ability to articulate their skills and identify examples they could use in job applications or interviews. This finding was reinforced by student comments in focus group discussions:

> It is a good sort of almost bank of information….So in the future, if I have an interview, I can literally look over them all….and think, "Oh, I did that in the Chemistry lab. I can use that as an example".

A majority of students also indicated that the reflective task caused them to pay more attention to what they were doing and think about the skills used, to acknowledge their skill capabilities and to identify skills they could improve.

> Because it's really helpful to have an idea of. I know I'm going to have to apply for something eventually, and then you have it brought to the front of your mind when you're doing these things, so you don't get to the end and go, oh my god, I can't apply for anything. You go, I have got some skills in there I can talk about and use.

A majority of students also indicated the reflections had helped them make more sense of their experiences, better understand the purpose of assessment tasks, and helped them gain more from the unit. These were all benefits students also identified in the volunteer program. Very few students saw no benefit at all in the reflective task. These findings suggest that incorporating such reflective tasks in the curriculum could be used to address the weakness in skill articulation of STEM and other students identified in prior studies (Nielsen & Holmegaard, 2016; Tomasson Goodwin, Goh, Verkoeyen, & Lithgow, 2019).

The motivation to engage in career management behaviours was a much stronger theme in the voluntary semester-long program of reflection than when reflection was embedded in the laboratory curriculum. Some of the key differences between the two interventions were that the volunteer students involved in the semester program were likely to have had greater intrinsic motivation, it included an evidence-based introduction to the importance of employability skills, involved recording reflections in an online platform, and included discussions and support from a tutor or mentor. Incorporating one or more of these program elements in the curriculum might lead to a stronger link between reflecting on employability skills and enhanced career management behaviours.

A fifth of students found the in-curriculum skills reflection task difficult. Qualitative data indicated some students believed the reflective task implied that they must reflect on the development of a significant new skill, which they did not believe occurred in each of the relevant experiments, as this

was not the first time they were developing such skills. One student stated about the skills reflection:

> We're not really learning the skills. Like everyone knows how to communicate, everyone knows how to work in a team

These students did not recognise that they could simply reflect on how they demonstrated a skill within a specific experiment, or on their gradual improvement through repeated practice. Emphasising the latter aspects when introducing the task may have helped some students in identifying what to write about. A small number of students also indicated that sometimes there was a mis-match between the skills badges displayed on the laboratory task and the skills they felt they used or developed in the experiment. It is important to clearly communicate to students whether they are required to reflect on the badged skills, or whether they can reflect on whichever skills are most relevant to them in an individual experiment (or other task).

Students who didn't like writing the reflections (just over a third) indicated that this was because it felt 'artificial' or disconnected from the rest of the laboratory, was an annoying extra task, or because it could be responded to disingenuously.

> I found it kind of, taxing, somewhat tacked on at the end. After like, write your lab report okay I'm finished my conclusion, done all that, and then it's like oh, here's this thing at the end.

> Oh, it's definitely something like, "what do they want to hear for that mark?"

Another commonly expressed frustration was a lack of clarity around task expectations and inconsistent marking by TAs. Some students also felt that they didn't need the reflections, as they had good skills recognition already, or believed technical skills were more important to their employability than transferable skills. A number of students indicated a dual response to the task; whilst some aspects were tedious or annoying, they also saw its benefits.

> I sort of agree, how most people see it as "It's an easy mark, it's got no relation to my life or anything, I'm just doing this to get a mark on the prac-" ….. But at the same time, I think it's a good first step into having people realize what skills to be able to use in interviews, to be able to talk about them when going for a job or anything like that.

> Every week I'm like, "oh great. I have to write this again". But if I did go to an interview, I I'd be like oh yeah, I used initiative here.

This explains why although less than half of students liked the task, about three quarters indicated they benefited more than a little from it.

Overall, the graded skills reflection task incorporated into laboratory activities seemed to initiate a complex interplay of motivations and reactions, that were likewise reported by Bufton and Woolsey (2010) in their mixed methods study on the impact of incorporating compulsory reflections in a first and second year core unit of a social science degree. The researchers from the latter study concluded that students' responses to the eportfolio and reflective tasks were complex. Approximately half of the surveyed students reported that they found such tasks helpful in reflecting on and analysing their progress, identifying areas needing improvement and presenting evidence of their skills and experience to potential employers, in agreement with benefits identified in this study. Some students also raised negative reactions to the reflective tasks, as observed in this study. One student felt that reflection had helped them in the first year of the degree, but written reflections were unnecessary later. Another student felt it would have been more useful if more integrated into the degree. One student said the reflections were pointless and hated by students,

with reflections completed at the last minute and often disingenuous, with students writing what they knew they 'had to write'. The latter echoes the comments made by a few students in this project. Another student stated that they were uncomfortable with reflection being assessed because it can't be right or wrong - it is personal; a view that was also raised by a student in this study.

The fact that some students felt the reflective task in this study was artificial, annoying or disconnected from the rest of the laboratory may be related to students' beliefs about the purposes of laboratory tasks and what they are seeking to gain from them. George-Williams et al. (2018b) observed that more students thought the aims of laboratory practicals were to better understand or apply theory or develop practical laboratory skills than to prepare for a career or develop transferable skills. Likewise, DeKorver and Towns (2015) identified students' goals in the laboratory were predominantly to finish the experiment early, avoid mistakes, achieve a good grade, and learn some laboratory techniques and technical skills, with few students identifying preparation for the future or development of transferable skills.

Students in several elements of this study expressed the importance of laboratory skills for those seeking employment in a science field, with some indicating laboratory skills were more important to them than transferable skills.

> Technical skills ….I feel like that's what's important in terms of employability, rather than all this other stuff [like] teamwork and initiative.

The findings of Ogunde, Overton, Thompson, Mewis, and Boniface (2017) on the career aspirations of chemistry students indicated that a majority of students (55% of Australian and 80% of UK students) were planning a career that uses chemistry. In a study by Galloway (2017), chemistry undergraduates seeking a 'chemistry occupation' rated the usefulness of chemistry knowledge/instrumentation skills significantly higher than those seeking an 'other occupation'. Consistent with this data, in the skills survey from this study, second and third year Monash students identified laboratory skills in the top four or five skills desired by employers and the skill they would most like to develop further in their degree, and for Warwick third year students, it was the second most common skill desired for further development. It is clear that many second and third year students studying chemistry strongly desire to develop laboratory skills. It is possible that these students may recognise that transferable skills can be developed in a range of contexts, including work and extra-curricular activities (Tomlinson, 2008), but that the laboratory is their only opportunity to develop laboratory skills, and hence development of laboratory skills is their major priority in the laboratory context. In support of this conclusion, Jorre de St Jorre, Elliott, Johnson, and Bisset (2019) reported some science students who are targeting a scientific career are concerned that a focus on transferable skills will dilute their discipline skill development and leave them unprepared for the workforce. Students with the view that development of laboratory skills is the major (or only) priority in laboratory tasks may be hard to engage in transferable skills or employability related initiatives in a laboratory context. It would seem important to emphasise to such students that employers are seeking graduates who possess and apply both transferable and technical skills, even for laboratory-based roles. Hence, developing both types of skills and the ability to evidence and articulate them in a laboratory context will increase their likelihood of success both in the recruitment process and in the scientific workplace.

Correlations were observed between understanding the purpose of the reflective task or being given information on how to reflect and realising a range of benefits from the reflection task. An improvement requested by both students and TAs was to ensure students are provided with a clear

introduction to the task at the start of the semester, including its purpose, benefits and expectations of length, structure, which and how many skills to address and where further supporting resources can be found.

> So I think maybe our first lab or at one of our lectures, at some point, you should discuss the importance of these employability skills and why we're looking at them….And explain how to answer the question… Because to date I'm still lost.

> I think that just maybe like, first lab. Just a bit of a focus on it. Like this is why we're doing it, this is…how it works….This is what you can do. This is where the help sheet is.

TAs requested training in order to understand the specific information they should share with students about the purpose and structure of the task.

> Even just an intro at the start saying, "Okay," just a little presentation for 10 minutes sort of just tell us some key points to focus on. … because without that, I'm just sort of left to my own.

Students also suggested that TAs briefly introduce the relevant skills at the start of each session and where they will be important in the experiment, so that the skills are more integrated into the experiment (rather than just an 'afterthought') and students can think about them during the practical.

> The demonstrators need to be like, just a few words about it, so to kind of bring it to your mind at the start of the lab, just so you kind of think about it. And I reckon that would make writing it more important, and also probably easier. Cause you'd be like oh I've been thinking about this the entire time, I'm really conscious of what I've been doing.

> Before the lab they could be like, in this lab we're trying to really improve your team working skills or your math skills or whatever. Kind of like zoning in on that so that you know that's what you're working on.

Some students suggested having a brief skills discussion at the end of laboratory sessions where they share thoughts on which skills they've used in the laboratory, so they genuinely engage with the task and identify some ideas for reflection.

Several students also suggested providing a specific framework for the reflection, such as the STAR approach (MacCallum & Casey, 2017; Tomasson Goodwin et al., 2019), which could immediately link the task to an employment context. To allow students some flexibility, a specific reflection framework was not required, but a number of prompt questions were listed in the help sheet. Unfortunately, many students were unaware of the help sheet. To ensure all students see the prompt questions in future, they could be provided on the pro forma with the task instructions. Some TAs also suggested making a more direct link to employment in the task instructions to help students to recognise its purpose, or asking students to reflect in response to a specific job interview question, which could be varied between laboratories.

Certainly, one of the findings from the voluntary skills reflection program was that many students found it helpful to have a framework for reflection (the STAR approach) and some prompt questions, although a number of students wanted more flexibility in applying the framework. Some of the students felt limited by the STAR framework's emphasis on success; that is, they did not feel it allowed them to reflect on instances where they failed or identified an opportunity to improve.

> The prompts were a bit too rigid, in the sense that It sort of forced you to talk yourself up in a way; like you know, talk about what you did well, rather than giving the opportunity to maybe also reflect on what you didn't do well in.

However, a recent study of students from 44 undergraduate units (Tomasson Goodwin et al., 2019) showed that students who engaged in skills reflection using a STAR approach four times during an undergraduate unit (three with grading, one as a peer-reviewed practice), supported by a skills list, sample reflections and an interactive marking rubric were significantly better at articulating their skills six months post unit completion than students who had not participated in this intervention. Students in another recent study also saw benefits in a structured approach to reflecting on their experiences (Reid, 2015), in this instance using SEAL - Situation, Effect, Action, Learning. This illustrates that using a STAR or similar skills reflection framework could be a successful approach to improving students' skill articulation abilities.

A few students and a TA raised the issue that when reflections were implemented in the chemistry laboratory curriculum, it was possible for students to repeat reflections in subsequent weeks due to having different markers each week. This issue could be addressed by requiring students to write their reflections for a specific unit in a single online document that builds with each reflection, so it would be immediately obvious if students were to repeat a reflection. This approach could have several additional benefits. Students could become more conscious of their progress over time, as they would have immediate access to prior reflections. In addition, it would result in students compiling a single document for that unit containing multiple reflections, which could be a valuable resource in the employment recruitment process. This approach could be considered a type of simple 'eportfolio'. An eportfolio may be defined as an online collection of evidence of student learning over time which can include a broad range of digital artefacts (including reflection), often implemented at a whole of university or degree level (Eliot & Turns, 2011; Kehoe & Goudzwaard, 2015; McAllister, 2015). Much of the historical use of eportfolios has focused on the cross-curricular or 'whole of self' development of students. The proposed approach in this study would be a simpler eportfolio; an online space for students to reflect on their skills developed in tasks throughout a particular unit. By focusing on one unit (rather than the whole degree), educators would have the ability to draw students' attention to the specific skills developed in relevant tasks, rather than relying on students to recognise this information for themselves, potentially missing the development of key skills. Outcomes from implementing a unit-based reflective eportfolio have been researched in a science pathology course, with student gains reported in recognition of skill development, perception as professionals and career awareness (Polly et al., 2013).

The Monash University Student Futures platform used by volunteer students in this study could be considered a type of eportfolio. It can be used to reflect on tasks from any unit in which a student is (or has been) enrolled. Students nominate a task or experience from the unit, link it to a skill they believe they demonstrated and reflect on it using the STAR approach. Academics in charge of a unit can assign students reflective tasks to complete in Student Futures, so this platform could potentially be used for the purpose described above. Students who used Student Futures in this study liked the fact that the reflections were all stored together and could be exported as a resource when preparing for job applications or interviews. They also appreciated that Student Futures summarised the skills they had reflected on and they could quickly review their reflections and assess where their skill strengths were and identify gaps in their skill 'evidence'. They liked having a list of skills to refer to, prompt questions to reflect on and a guiding structure.

> On the main page, it says like you've built on three out of nine skills and I think that's a good one, to like realise where my gaps are.

> I find that the prompt questions … really help. ... it like helps you kind of structure it a lot more and it makes it a lot quicker to answer as well because you just basically answer the questions in a sense.

> Having the structure kind of forced you to step out and like, what did I actually do?…. it made you kind of step out like, this is what was learned, this is what happened, this is what didn't end up happening, this was the result. I like how it stepped it out like that, otherwise I just would've written less.

However many students felt limited by the platform's inflexibility and repetitive structure. The fixed structure required students to choose a descriptive statement and a specific situation before commencing the reflection e.g. "Describe a situation when you used initiative and created enthusiasm and support to make things happen". Students felt such statements were quite prescriptive and always signified positive achievement. Some students desired more flexibility in how they reflected so they could reflect on failures and learning gained through making mistakes and also identify additional skills learned about or developed beyond those prescribed. They also desired the ability to reflect on gradual development over time rather than always reflecting on a single event or situation.

> It was good that they gave you guidance but it could be a bit more flexible.

> I'll sort of know the situation and try to find an option that like relates to it. It's not so easy to find something ... It probably would be a bit better to have one you could add yourself.

> But I feel if you had a few prompts that point out the negatives, it would like show your growth over a period of time, because now I feel like it just shows things I've done that I'm really good at, but there are definitely things I've done that I haven't really excelled in. So you could have like a category to say maybe something a bit negative, so you can see …. like a gradual growth.

Rather than facilitating learning through reflection, the Student Futures platform appears more suited to gathering and articulating specific evidence of a pre-defined skill set for employment, which is consistent with its stated purpose: "This online platforms helps you identify, record and present the employability skills you acquire during the course of your study". Allowing students more flexibility in applying the reflective process than is provided by Student Futures may facilitate deeper learning about their skills and provide the opportunity to use the reflective process to further their development.

Finally, it is important to consider the issue of allocating marks to the reflective task. Extrinsic rewards such as grades are sometimes known to cause detrimental effects. Creten, Lens, and Simons (2001) report that extrinsic rewards which involve evaluation, 'coercion' or time pressure, for example, may undermine intrinsic motivation and decrease the quality of learning because they may lead to haste, lower concentration or change of focus. However, research also indicates extrinsic rewards such as grades do not have to have a detrimental impact if they are implemented thoughtfully and with a conscious focus on the desired outcome. That is, if they are implemented such that 'their controlling aspect is much less salient than their informative aspect' (Creten et al., 2001) and the focus is on increasing student confidence and self-efficacy and retaining self-determination. Under the latter conditions, extrinsic rewards such as grades may increase intrinsic motivation and interest in the learning task and may even assist some students to develop an intrinsic interest in the task.

In this study, when skills reflection was initially used in the volunteer program, no grades were attached. In this program, the majority of students involved reported significant benefits from the reflective task, but they also reported difficulty in finding the time and motivation to continue, especially in the midst of assessments. A number of these students requested skills reflection be incorporated in the curriculum because of its benefits and also requested it be associated with a grade, to enhance motivation and prioritisation.

> I kind of found the hardest thing, was just motivating myself to do it, …Whereas maybe if it was integrated into a unit, then maybe marks could be allocated and that would actually motivate kind of everyone to do it. Because I think it's a really effective kind of tool, especially when you're building your resume,

When skills reflection was incorporated in the undergraduate chemistry curriculum, a small grade was associated with it, based on the learning from the volunteer program. Whilst some students found aspects of the grading frustrating (such as unclear guidelines and grading variability between TAs), a number of students explicitly stated that without a mark attached, they were highly unlikely to complete the task.

> It's probably a good thing that it is marked. Cause like, if it wasn't marked or whatever, people would be like oh yeah, whatever, stuff it. But since it's marked it makes you think about it, because you feel like oh yeah I gotta get that extra mark, cause who knows it might boost my grade a little bit more.

Such comments support the findings from the volunteer program and the conclusion by academics in Sarkar et al. (2019) that students only take tasks seriously when they are awarded a mark. The approach taken in this study to incorporate skills reflection in the curriculum and associate marks with it is also supported by the findings of two other contrasting studies. The Tomasson Goodwin et al. (2019) study mentioned above illustrated a graded in-curriculum skill reflection intervention that resulted in a significant increase in students' ability to articulate their skills whilst, in a Jackson and Edgar (2019) study, very few students completed an extracurricular ungraded career development intervention run at several universities. In the latter study, whilst students found a workshop about the importance of and how to articulate their skills in the employment process helpful, uptake was very low on a skill articulation task providing feedback from an industry professional. Students indicated that they of necessity prioritised the latter task below assessed tasks in their degree, in agreement with the feedback from students who participated in the volunteer program in this study. A major recommendation from the Jackson and Edgar research was to incorporate such initiatives into the curriculum as assessed tasks, noting also that students value personalised (rather than general) feedback. Such findings indicate the importance of associating a grade with a skills reflection task to maximise student participation, engagement and benefit.

Whilst attaching a grade to the reflection task is key for student prioritisation and engagement, it is unlikely to produce significant benefits for a student who is entirely extrinsically motivated (such as one who cares only about grades, financial reward or impressing others, rather than learning itself). Such a student is likely to simply do the minimum necessary to 'get the mark' without engaging in meaningful reflection or connecting with its purpose or wider potential benefits, as reported by a student in the Bufton and Woolsey (2010) study discussed earlier and several students in the current study. It is also likely to be hard to engage students with the skills reflection task who only want to focus right now on their degree, as they will not be interested in or motivated by its purpose. Findings from the laboratory skills reflection research indicated that the proportion of such students to be around 28%, similar to a recent study of chemistry undergraduates in Australia, NZ and UK, in which 18-26% of students said they didn't want to think yet about what they will do after graduation (Ogunde et al., 2017). Correlation analysis from this study supports the hypothesis that students who are focused only on their present degree studies and grades are likely to be less engaged with and experience fewer benefits from employability skill recognition or articulation initiatives.

Whilst students who are entirely extrinsically motivated or not interested in employment preparation during their degree are unlikely to benefit as much from the reflective task, most still appear to experience at least a little benefit. Some students suggested continuing the reflective task

through the third year of the degree, but at reduced frequency. This would ensure students continued to notice their skill development in the final year of their degree and continued to link their university experiences to future employment. Reducing the frequency would ensure that the task didn't become too monotonous through excessive repetition, and associating it with 'high impact' tasks such as multi-week laboratories or projects would offer wider scope for skill development and reflection.

Overall, the findings from this part of the study indicate that writing skills reflections can enhance student recognition of curriculum-embedded skill development and enhance students' ability to articulate and provide evidence of their skills. However, it is important to carefully consider how the reflective task is communicated to students, structured, implemented and supported and graded by TAs, in order to minimise student frustrations and maximise student engagement and benefit obtained. It is possible for students to be disingenuous in a graded reflection simply to "please the lecturer" and get the mark, as noted by Barnard (2011) in her study of student reflective learning journals. However, Barnard concluded that "although imperfect", such reflective assessment can be "useful and effective" if "students are given time and space for exploration, and as long as they are well guided and given training and practice". The outcomes of this research suggest a similar conclusion, provided teaching staff also explicitly communicate the purpose of the reflective task to students.

7.3 The impact of displaying skills badges in the curriculum on students' ability to recognise and articulate transferable skill development

Findings from the skills badging intervention and implementing skills reflection in the curriculum in the presence of skills badges indicate that signposting skills by displaying badges on task and assessment instructions can increase the recognition of specific skills. This finding is particularly true for skills that were less well recognised by students prior to the intervention, with some students explicitly stating that the badges helped them identify skills that they would not otherwise have recognised. As one student stated:

> [The badges] provided extra skills that I wouldn't normally associate with assignments / tasks.

Students articulated that without any prompting, they are inclined to be entirely task focused and unconscious of transferable skill development opportunities within the curriculum. This is consistent with findings by George-Williams et al. (2018b) (as mentioned earlier) that science undergraduates believe the main purposes of doing a practical chemistry course are to better understand discipline theory, apply that theory and develop practical skills, with little or no attention given to transferable skill development in this context. Students' overriding task and discipline knowledge focus also helps explain why, when prompted in this study to identify which skills they have developed during their degree, students were only able to identify an average of three or four skills and a very narrow range of skills. Students' narrow focus and lack of awareness of skill development within the curriculum emphasises the need for an explicit intervention such as displaying skills badges or introducing a skills reflection task.

When transferable skills badges were displayed on learning resources or assessment tasks, students identified the following additional benefits: alerting them to the skills required by a task, which helped some students feel more prepared; communicating a clearer or wider purpose for the task, which increased some student's motivation; helping students recognise specific skills they had developed during a task, which led to greater satisfaction for some students; and highlighting

specific examples some students felt they could use in job applications, providing a link between university tasks and 'real life'.

> They were a fantastic addition to the lab manual & provided us with an idea of how the skills from lab work can translate into good industry practices in the future

> Badges helped when delivering examples in interview; helped focus answer

When skills badges were displayed without a reflective task, half to two thirds of students said they were a positive addition to the unit, with two thirds agreeing they helped them recognise skills they could develop in the unit and half agreeing that they helped them think about skills, not just the unit content.

When skills badges were used in combination with a reflective task on skill development in the laboratory, the badges were seen to be a positive addition to the unit by half to two thirds of students, an almost identical result to when badges were used without reflections. The major benefits identified in the latter context were that they were a great starting point for writing the reflections, they made a direct link between laboratory tasks and the skills needed in employment and widened students' skill recognition beyond the skills that were most obvious to them (typically teamwork and communication). Thus, for approximately half to two thirds of students, displaying skills badges (with or without a reflective task) appears to provide a link between curriculum tasks and employability as called for in prior literature (Bennett et al., 2015; Jorre de St Jorre & Oliver, 2018; Kinash et al., 2018; Wakeham, 2016).

As mentioned above, one of the benefits of the skills badges identified by many students was providing a wider, clearer or new purpose for curriculum tasks. As one student shared:

> They certainly helped to identify the purpose/intention of the practical exercises.

This same benefit was also identified by students from engaging in reflection on skill development from the curriculum (whether through the volunteer program or embedded in the curriculum). In each case, a number of students stated that prior to the intervention, some tasks appeared to have no obvious purpose to them and they had seen such tasks as being of no benefit. By observing the skills badges associated with the task or reflecting on the skills developed through the task, for the first time these students identified a specific purpose for such tasks in the development of important employability skills. This supports the assertion of Kinash et al. (2018) that the link between assessed tasks and employability must be explicitly pointed out, otherwise students are unlikely to recognise it.

Once students recognised that skill development was a purpose and potential benefit of the task, as a result of the skills badges or reflections, many reported enhanced motivation to complete the task and engagement with it. By helping the students to identify a clear purpose for the task, the skills badges or reflections increased the value of the task in these students' eyes, increasing their motivation.

> It gave me motivation where I was like, I'm not trailing through this for nothing. I'm actually getting stuff out of it. … It just showed me that I'm getting some skills out of it that I can use.

> I did like the idea of [the badges] particularly for the [specific] project because … some friends and I were just like "What does this have to do with this unit? What is the point of this?" But actually seeing which skills we were supposed to be developing out of it .., it also kind of helped motivate us to do it because it didn't feel so random.

Value, or whether students 'care about or think the task is important in some way' is presented as one of the key determinants of motivation in the literature (alongside perceived competence or efficacy, relatedness and autonomy) (Blumenfeld, Kempler, & Krajcik, 2006; Pintrich, 2003). Making connections between learning tasks and employability skill development can lead to increased perceptions of the 'instrumental' or 'utility' value of the task, that is, 'how tasks are related to future goals and everyday life' and the usefulness of the task to them for other aspects of their life beyond the immediate curriculum situation, leading to enhanced motivation (Blumenfeld et al., 2006; Creten et al., 2001; Hulleman, Durik, Schweigert, & Harackiewicz, 2008; Pintrich, 2003).

Blumenfeld et al. (2006) emphasise that motivation is critically important because it is a foundation for cognitive engagement with a task. Without sufficient motivation, students may only superficially engage with a task, paying only just enough attention to complete it using low level learning strategies. Motivation can lead to deeper cognitive engagement: students may be willing to explore the material or task more deeply, make connections to or reconsider prior knowledge and learning experiences and critique their work, resulting in deeper understanding and increased achievement. If the skills badges and reflections can increase the value of a curriculum task for some students (through linking it to enhanced employability) and hence increase their motivation towards it, students are likely to learn more from completing it.

However, understanding the purpose of the badges and their link to employability is key in order for students to value them and hence engage with and benefit from them, as described above. In this research, approximately one fifth of students didn't find the badges meaningful because they lacked this understanding. As one student expressed:

> They weren't really announced so I wasn't really aware of what they meant or represented.

This was found to be the case both when the badges were used alone and in combination with the skills reflection task.

When the badges were used without reflection, students requested that staff talk more about them. Students asked for staff to describe the purpose of the badges when introducing the unit at the start of semester, and explain how students can use them and benefit from them. They also asked for staff to briefly draw students' attention to the badges at the start of each laboratory session or workshop throughout the semester, and link them to activities.

> The skills badges were very useful but often overlooked, as the TA's failed to address them most of the time. Staff should emphasise these badges to enhance usefulness.

> Just be like one 10 minute explanation at like the first lecture; just [displaying] them all, what they mean and how you can use them, just really briefly …..and maybe one at the end of the unit as well. So just to increase the awareness of what they mean and how you can utilize them.

> I think even at the start of every lab, if the TA is just like, "Oh, these are the skills that you're going to gain today," as simple as that…. because it's going to be in your mind so you're going to be thinking about it as you go along.

When the badges were used without reflection, some students believed they would gain more from them if they completed a written reflective task or participated in a discussion about them. Likewise, a few students that experienced the skills reflections in the curriculum in the presence of the badges, stated that they would have ignored the badges without the written reflective task. For such students, writing skills reflections helps to draw their attention to the badges and encourage them to think actively about the skills they have developed, rather than ignoring their implications.

Students who were disengaged with the badges when used without reflection identified a number of reasons for their disinterest. Some didn't understand their purpose or how to use them; felt they were repetitive (same badges used too many times) or were redundant (when the skill was self-evident); felt they already had good recognition of skills and didn't need them; or that they would value other employability initiatives more, such as internships, authentic tasks or examples of career paths and opportunities. Some students requested a greater range of skills badges across weeks, so that a greater breadth of skills would be brought to their attention.

Two concerns raised by TAs were that the badges might make the students worry about their employability or narrow the students' view to just the badged skills, missing other skills they may have developed or that are needed in employment. It is important for TAs to speak positively about the opportunity for students to better recognise their skills and build their employability, as their attitude and approach are likely to influence how students perceive their prospects. TAs can also encourage students to look out for additional skills they may be developing, and the TAs could also comment on any other skills they observe, as it is not possible to provide an exhaustive list and individuals may have different experiences. Identifying skill development is an important attribute of lifelong learners throughout their career and an attribute students can be encouraged to begin to develop, building on the skills badges as an initial prompt.

The main drawbacks of the badges identified by both students and TAs when combined with the skills reflection task were that they made the task too easy for some students, as they didn't have to think for themselves. One student shared:

> I basically sort of leaned on those icons, as a crutch, for the report. So it's like, "All right, this reflection, what does it need? It needs these three icons. All right, I'll make sure I include those, and then I'm done with it," rather than actually going back and, thinking through it….rather than actually having a proper reflection.

The badges also tended to limit many students to the displayed skills, rather than identifying the skill(s) that may have been most prominent or meaningful for them personally (reflecting the TA concern raised earlier). A number of students suggested scaffolding skill recognition by displaying the skills badges on each laboratory experiment for a semester, but including only a summary page of the badges in the laboratory manual in subsequent semesters, along with some post-laboratory discussions about skills. Whilst a skills list could replace the badges summary in this instance, most students found the badge icons visually appealing and more impactful than words alone and they would provide a visual prompt and reminder of the badges displayed on individual tasks in prior units. Some TAs agreed with removing the badges from individual experiments but retaining the summary, so students would be required to think more independently and broadly about the skills developed.

> I feel like the badges should be there, but not like a specific badge for a specific experiment kind of thing… because I feel like if you assign it to a specific experiment, they will just like, okay, this is the answer.

However, a student and a TA both raised the concern that this may lead to a more narrow skills focus by some students who might only reflect on the same few skills repeatedly.

There is a tension here. Removing the badges from each set of instructions would potentially make the reflective task more open-ended and challenging, as students would need to identify their own skills on which to reflect. It could also make it more personal to their experience, as they would ideally be identifying skills they felt stood out for them in that task and they could refer to the

summary page of the skills badges for ideas. However, findings from the skills survey and skills reflection research clearly indicated that for students to recognise a broader range of skills, educators will need to make these skills explicit. Displaying skills badges on specific tasks, and at key points within the tasks, can highlight situations where students are using skills they are unlikely to recognise for themselves such as creativity and innovation, professionalism, initiative, independent learning, flexibility or adaptability and commercial or industry awareness. Without skills badges, it is likely that students may again revert to only identifying and reflecting on the 'obvious' transferable skills (such as teamwork and communication) in the absence of links to other skills, as was evidenced in the outcomes of the skills survey from this study. If the badges were removed, asking staff to facilitate a brief skills discussion to encourage students to think more broadly about their skills may assist. This was a suggestion made by a number of students, although some staff were unsure whether there would be sufficient time for a discussion at the end of every experiment and not all TAs may have the skills and experience necessary to successfully facilitate such a discussion.

It is notable that there was no mention of career management thinking or behaviours associated with the skills badges, suggesting that reflection may be needed for students to take their employability to this next step.

The findings from awarding skills badges to students on completion of assignments in one unit indicated that whilst students noticed these skills badges, they did not have a greater impact than displaying badges. In fact, they engendered more negative reactions; more students said they were unhelpful or distracting and that they weren't meaningful. Students indicated they would have preferred badges to be awarded on merit, rather than as a 'participation award', which seemed childish. They indicated they would like any future awarding of badges to be based on achievement levels (such as bronze, silver and gold), with multiple opportunities to develop skills and achieve progression.

Overall, both the badges and reflections helped many students identify specific examples of a range of employability skills developed during their degree. Thus, they help address a key finding from studies of STEM graduates that such graduates struggle to identify their relevant skills and competencies when applying for employment (Nielsen & Holmegaard, 2016; Wakeham, 2016).The skills badges play a key role in helping students to identify less recognised skills which writing reflections may not always achieve. In the absence of signposting by skills badges (or other means), reflection requires students to notice and identify relevant skills for themselves, which this study suggests science students may struggle to do for many skills, especially without prior training or intervention. The key role of the skills reflections is in helping students to develop the ability to put their skills into words, which Nielsen and Holmegaard (2016) reported physics graduates found difficult to do. In short, skills badges can help students to recognise a much wider range of skills developed during their degree and reflection assists students to develop the ability to articulate their skills, helping bridge the "articulation of skills gap" noted by Tomasson Goodwin et al. (2019).

7.4 The impact of skills badges and a skill reflection task on Teaching Associates (TAs)

Teaching Associates who delivered workshops and laboratories to students in the units displaying skills badges reacted in a number of different ways to the badges. Some TAs seemed unaffected by them and were focused on ensuring that students achieved the relevant discipline content or technical skills and didn't pay much attention to the badges or skills. However, they didn't

believe the badges were a negative addition and thought they may have been helpful to some students.

Other TAs felt that the badges were a good addition for students as they helped them realise they could gain specific transferable skills from curriculum tasks in addition to discipline content and skills, identify which skills were important and help students better prepare to apply for work and research roles post-university.

The TAs that were more engaged with the skills badges also indicated that the badges prompted them to talk to students about the skills involved with each curriculum task or to be more conscious of and modify their teaching approach to ensure they delivered the highlighted skills.

> What are the benefits of doing this practical? So like if [the badges] were not there I would have never thought that I need to tell this to my students, to-be honest, right. ..It's a prompt for me to step up and tell the students.
>
> I would say that it has caused me to realize more the importance of delivering the skills that are highlighted. So it got me thinking as well and I guess it's sort of shaped my teaching in a way..... I would look at the badges and be like, OK. These are the skills that they need to take away.

It is possible that a TA's own interests and prior experience and knowledge of transferable skills or employment may have impacted their reaction to the skills badges. Many sessional staff (TAs) in Australian universities are undertaking or have recently completed a PhD (Jepsen, Varhegyi, & Edwards, 2012). Many of these may have little or no professional work experience (scientific or otherwise), and little or no experience with how skills are applied in a professional workplace. Some may be highly research focused and have little interest in employment outside academia, with 56% to 75% of sessional teaching staff believed to be seeking a long term academic career (Hitch, Mahoney, & Macfarlane, 2018). Such TAs may feel little interest in or motivation to talk to students about transferable skill development or preparing for employment outside academia, or may feel they lack the expertise to do so. Some may feel it is not their role to do so. In order for students to gain the most benefit from the skills badges (or other employability related curriculum initiatives), it is important for academic staff in charge of relevant undergraduate units to try to engage more TAs with the skills badges. This might be achieved by talking to the TAs in advance about the purpose of the badges, providing evidence on the importance of the represented skills and encouraging them to talk to students about the transferable skills they can develop in the relevant curriculum tasks; emphasising the value of the skills in all post-university career paths, including research and other professional careers.

The teaching staff involved in the two chemistry units which included a skills reflection task were required to read and grade the completed reflections, and most expressed some reaction to doing so. A number of TAs indicated that reading the reflections gave some insight into student learning and the impact of their own teaching, at times leading to pleasure and satisfaction. A few TAs also experienced frustration if they felt that the reflective task was poorly understood or performed. One TA expressed a lot of satisfaction when students recognised weaknesses through their reflection, and identified strategies to improve.

> In the end, I really liked, I really enjoyed and felt satisfaction reading a lot of them, because .... they really identified what they did wrong in terms of their attitude and their general demeanour and the skills that they were lacking.

These observations suggest that the reflections may at times provide some feedback from students to staff within the teaching period, giving some insight for staff on aspects of student learning,

strengths and weaknesses and highlighting teaching strategies or activities which have been effective. It could be beneficial for both staff and students if staff use these insights to target their future teaching and communications; repeating past successful strategies, supporting students in addressing their weaknesses or pointing out the potential benefits of curriculum activities. As Richardson and Radloff (2014) assert, "the actions of teaching staff are critical in inspiring, challenging and engaging students". Skills badges and students' written reflections on their learning experiences may be some of "the building blocks which bring together staff and students as learning allies" through helping TAs better understand how to assist students to connect their curriculum experiences to their future and gain more from their curriculum tasks.

7.5 Factors that may influence the impact of skills badges and skills reflection tasks

The findings of the study indicate that there are a number of factors that may influence the impact of the skills badges and skills reflection interventions. Whilst these factors were identified during the evaluations of the interventions above, they are gathered together in this section to discuss in more detail why each is important and how they might be able to be applied or approached to increase the benefits of the two employability interventions.

Explicit communication with students about the purposes and benefits of employability interventions and tasks related to skill development

A strong theme that emerged from both interventions was that students want teaching staff to explicitly communicate the purposes of tasks and assessments and their potential benefits, including embedded skill development and employability enhancement initiatives such as the badges and reflections. Students made it clear that they don't recognise skill development as the purpose of some assessment tasks (which appear to have no obvious purpose to them) and they wish to better understand the purpose of such tasks. As discussed earlier, when students realise the purposes and benefits of tasks, they are more likely to feel motivated to complete the task and be engaged with it.

In the laboratory skills reflections data, correlations were observed between understanding the purpose of the reflective task and realising a range of benefits from it. These quantitative relationships were supported by qualitative data: Students who shared that they initially hadn't understood the purpose of the task, felt it was of no value; but once they were provided with information about the purpose of the task and its connection to the job application process, they saw its benefits. The latter finding also emerged from the skills badges intervention.

Understanding why it is important to be able to express one's skills was also correlated with engagement and positive persistence with the skills reflection task. Understanding the importance of skill articulation was correlated with finding the skills badges beneficial and strongly correlated to students believing it is important to start preparing immediately for a job or career. This indicates that an understanding of why it is important to be able to write or talk about skills may not only impact on students' engagement with the skills badges and skills reflection tasks, but also on skill-related related employability activities within a degree generally.

Many students expressed a desire for staff to verbally highlight which skills were likely to be developed when introducing a task, and reiterate their importance. Doing so helps students to pay more attention to their skills during the task and they appreciate their attention being drawn to this dimension in addition to the task mechanics or discipline content. As one student expressed:

> Not much emphasis was put on the fact that we should be maintaining an awareness of these skills. More of a focus on them would help people deliberately develop them.

Students value hearing that their teachers believe these skills are important, relevant and useful.

These findings are consistent with prior research. O'Leary (2016) reported that 90% of undergraduates want employability to have greater emphasis in the curriculum and Bennett et al. (2015) report that many students believe their degree has failed to show relevance to the 'real world' of work and desire to see that connection, but need assistance to do so. The latter authors state that "the development of employability has to be delivered overtly for it to be absorbed by learners" and they call for explicit links to be made between learning and the workplace, either through learning outcomes or 'merely telling them, "Look what you've accumulated as a result of that presentation"'. As discussed earlier, the findings from this research indicate that links to employability through learning outcomes are insufficient and that students are seeking more obvious connections such as the latter approach (staff 'telling them') or other explicit links. Whilst the findings from this research suggest that the skills badges or reflective task can provide that explicit connection between university tasks and employment that is valued by students, it also highlights that if teaching staff bring such employability development opportunities to students' attention and explain their purpose and importance, the benefits of the skills badges and reflections are likely to be enhanced.

TA engagement and training

As a consequence of the previous conclusion that communication of the purpose and benefits of tasks designed to improve employability is critical for many students to obtain value from them, the role of TAs is very important.

In Flaherty and Overton (2018), TAs were asked how they could work with students to establish shared visions for their laboratory learning and one of their conclusions was that they could 'tie [students'] lab experiences to their future goals'. The skills badges and reflections could be one way of helping achieve this aim. In the Flaherty and Overton study, TAs also recognised that they have a significant influence on students' attitude towards their laboratory experiences and the discipline. TAs can instil a great variety of reactions in the laboratory, from inspiring students to 'losing' them; creating an environment where questions are welcomed or one that feels pressured and stressed; or they can focus primarily on getting finished rather than on the students' learning and development. Making time to mention the skills that could be developed in a laboratory learning session and connections to employment would require TAs to focus more widely on the purposes of the experiment beyond gaining technical skills and knowledge or getting the experiment done on time. TAs may need to be given explicit permission to do so by the academic responsible for the unit and be given explanations and evidence of the value and importance of doing so, to facilitate a small but necessary 'paradigm shift' for some TAs about the wider value of tasks (such as laboratory experiments) for students.

Flaherty and Overton talk about the need to help TAs broaden the conceptualisation of their role from transactional to that of a transformational leader who inspires students. Providing TAs with a little training in what to convey to students about the purpose, benefits and structure of the skills badges and skills reflection task may assist them to inspire students about the value and impact of their laboratory (or other curriculum) experience and help students gain more value from the skills badges and reflective task.

Group discussions about skill development

Many student participants articulated that discussing their skill development experiences with students and/or a facilitator widened their views and led to new learning and insights.

> Engineering doesn't offer a sit-down discussion like this, where you get to think about how certain things ... like, just here I've thought, hey all those presentations I've been doing I'm going to put that in my professionalism skills. Yeah, it's good.

> Probably this conversation has probably given me more information about the things that we were meant to be writing about than you've got in the rest of the unit combined….So…just having a little discussion about it within your group, that might be really beneficial.

This view was also reported by psychology undergraduates who participated in group discussions in a study by Clinton and Kelly (2017). This aligns with one of the findings from the Bufton and Woolsey (2010) study, where some social science students who had engaged in reflective tasks stated that solitary personal reflection wasn't always as beneficial as discussion with other students or tutors; that hearing someone else's thoughts can expand your view of a situation and your progress and learning. Group discussions are also believed to help engage students with a topic (Clinton & Kelly, 2017). In this study, a number of students indicated that they were more engaged with the skills recognition or articulation interventions at the conclusion of focus group discussions than at the start. In both the skills badges and laboratory skills reflections interventions, a number of students highlighted that discussing their skill development had led to much greater awareness and appreciation of it. This suggests that incorporating one or two group discussions about skill development within a unit involving skills badges or reflections may enhance the benefits gained by students and their engagement with these initiatives, or lead to benefits for students who had not previously seen value in them.

University year level

A study by Tymon (2013) of business, HR and marketing undergraduates indicated that first year and second year students had a very limited understanding of employability. Tymon hypothesised from this that students early in their degree may not really believe that employability matters and are not interested in employability skill development activities in the curriculum. Contrary to Tymon's conclusion, the findings of this study suggest that students are interested in employability skill development before their final degree year and that it is a lack of understanding of the purpose of skill-related interventions or the importance of employability skills that can limit some students' engagement, not being in the first two years of their degree.

Many second year students in this study were interested in employability skill development through the curriculum and believed they benefited from the two transferable skill interventions, when they understood their purpose. A significant number of second year students, particularly those in their first semester, did not appear to understand the importance of employability skill development and articulation and required teaching staff to communicate this information to them. Once this was communicated, many of these students expressed strong engagement with the interventions.

When skills reflection was attached to laboratory tasks, more CHM2911 students (who were primarily in the first semester of second year) indicated a high level of engagement with the task than CHM2962 students (predominantly in their second semester of second year or in third year). Whilst it cannot be assumed that the year or semester level of the students is a cause of this difference, it certainly does not support a hypothesis that students earlier in their degree are less interested in employability building activities. In fact, for the 'earlier' students, there was a sense

that employability was perhaps a novel and interesting concept that they were just beginning to connect to their degree tasks and their future. This new awareness appeared to be welcomed and appreciated by many of these students. For the first year unit included in this study (the CH155 laboratory unit at the University of Warwick in the skills badges intervention), whilst students didn't notice the skills badges as frequently at first because they were coming 'up to speed' with their laboratory skills, a greater proportion of these students responded positively to the skills badges ('was a positive addition to the unit' and 'increased the value I saw in this unit') than their end of second year counterparts (from the CH222 laboratory unit). Whilst this could reflect a cohort difference, it is the same trend as for the 'earlier' CHM2911 cohort compared with the 'later' CHM2962 cohort and again tends to refute the suggestion that earlier year students are not interested in employability initiatives, at least in the context studied here.

When students were asked in focus groups about the purpose or benefits of skills reflection in the laboratory curriculum, CHM2911 students were more likely to cite purposes or benefits associated with skill recognition, such as:

> First yeah Chemistry we did not have these questions, we did not think of these skills at all… making students aware that they are using these skills, then that's just one step in the right direction.
>
> Having to write about it means you actually think about oh what did I actually learn? And what skills have I practiced in the lab?

CHM2962 students were more likely to make explicit connections to employability (such as that the purpose was to connect laboratory tasks, skills development and future employment or that the task prompted them to think about their employability). For example:

> It's about improving our awareness of how what we are doing relates to our employment in the future.
>
> I wasn't so much thinking of the specific employability skills …, but it definitely made me think of the fact that OK, at the end of the degree I'm going to have to use the degree to get a job …. Because .. like you tend to forget. You're just doing your assignments, working from week to week, like I've got this due. But like, this sort of gets you thinking; OK what's the plan after finishing? What are you going to do?

Whilst CHM2962 students more readily made a direct connection to employment, they were also more likely to be negative such as saying the reflective task was forced or artificial, easy, prone to disingenuity, repetitive or unnecessary, because 'most students' already recognised their skills (with the latter objection not raised by CHM2911 students). These observations could suggest that this task as it was implemented might seem a little 'basic' to some students further advanced in their degree. Such students perhaps either had greater confidence in their employability preparation or preferred tasks that they perceived would have a more significant impact on their employability, provided new employability-related contexts or information, or were more directly linked to a specific type of employment of interest to them. Whilst some students who think they have good competence in skill recognition (and articulation) and don't need the reflection task may overestimate their ability, as Pintrich (2003) points out, if a student overestimates their current ability, they are unlikely to be motivated or engaged with tasks focused on improving it.

Despite the perceived drawbacks raised more often by CHM2962 than CHM2911 students, two thirds of CHM2962 students (and three quarters of CHM2911 students) saw multiple benefits in the skills reflection task. This interest in employability skill development throughout second year (and

into third year) is consistent with the results from the survey on skill recognition and value, wherein further 'job/career' skill development was desired by many Monash chemistry students at the end of second and third year (in the top five skills desired by second year students and in the top three by third year students).

CHM2962 students' evaluation of the skills badges when combined with skills reflections was less effusive however, with only half seeing the badges as a positive addition when incorporated with reflection (compared with two thirds of CHM2911 students) and significantly fewer (just over a third) believing the badges increased the value of the unit in comparison to when the badges were incorporated without reflection (compared with over half of CHM2911 students). This could suggest that in the latter half of a degree, removing the skills badges from tasks when students are asked to write skills reflections could be worth investigating, as suggested by some students and TAs. However, the badges appeared to be a valuable scaffolding tool for first semester second year students when writing skills reflections, assisting them to recognise skills they would not otherwise have associated with specific tasks.

Overall, the findings from this research suggest that students see significant benefits of employability building interventions such as displaying skills badges or skills reflection before the midpoint of their degree. This is consistent with responses to a survey question from the volunteer skills reflection research: when asked the best time for students to start working on their employability, most selected either second semester first year or first semester second year. Students had reservations about commencing skills reflections or badges in the first semester of the first year, as they felt most students feel overwhelmed at this point in their degree, due to the need to rapidly adjust to university tasks, systems, people and requirements. However, by the second semester, they felt many would be ready to take in new information.

If students do not recognise their transferable skills and haven't developed the ability to articulate their skills by the middle of the second year, they are likely to miss opportunities for internships, volunteering and end of second year summer work or research projects, as applications for these typically occur mid second year and require skill articulation. Likewise, the recruitment process for many graduate roles occurs at the commencement of the third year and if employability related initiatives are only delivered in students' final semester, as a capstone unit, they will not be of any benefit to students applying for such roles. In addition, if a focus on employability skills only occurs at the end of the degree, students will miss the opportunity to recognise and benefit from skill development experiences that occur throughout their degree. Whilst initially thinking employability related interventions such as reflection were best situated in late second year or early third year, after observing their impact on students, Rowland et al. (2019) also concluded that students would significantly benefit from such interventions earlier in the degree: "The opportunity to self-assess, set goals, and consider how to build a career using their science-related experience is crucial for students; we suggest they would benefit from starting early in their undergraduate degree".

In addition to initiating skills badges and/or reflections in the second semester of the first year or at the start of the second year, the findings from this research suggest it would be desirable to continue the skills reflection task into the third (final)year of the science degree, preferably associating it with larger tasks such as multi-week laboratories or projects. The students who suggested this approach felt it would ensure they don't forget about their developed skills and can maintain or further improve the ability to articulate them as they approach graduation.

Approach to grading of reflective tasks

The outcomes of this research broadly support the inclusion of skills reflection in the undergraduate curriculum and the assessment of such reflective tasks. However, some issues emerged about the specifics of grading the reflections and students and TAs suggested potential modifications to the grading to improve engagement with, or impact of, the reflections.

Some of the grading issues can be addressed by providing improved communication to TAs about the expected structure and content of the reflections, and the existence of a student help document, with an explicit request for TAs to communicate this information to students. There should also be more explicit communication to TAs about how the reflections should be graded, to avoid some TAs including additional marking criteria of their own.

Some students and TAs suggested increasing the number of marks associated with each reflection, as this is likely to increase the effort and value placed on the reflections by students. One approach would be to assign fewer reflective tasks but make each worth a little more (for example, a reflection every second week worth two marks). This would add weight to the task and reduce perceptions of repetition reported by some students from being asked to complete a skills reflection on every laboratory task. In support of this approach, the implementation of STAR-based skills reflection in the curriculum reported by Tomasson Goodwin et al. (2019) (discussed above) that significantly increased students' articulation abilities incorporated three graded skills reflection tasks across the 12 week semester, allocating them a minimum of 6% of the total unit grade. By comparison, students in this study were asked to complete five (CHM2962) or six (CHM2911) graded reflective tasks, typically a week apart, worth five per cent of their laboratory grade and approximately 1.5% of their total unit grade. This suggests that reducing the number of reflections but increasing the value of each could maintain or increase beneficial outcomes for students.

Another TA suggestion was to separate the task from individual laboratory reports and instead ask students to reflect online every few weeks about the skills they'd used in the laboratory, again for a higher mark weighting, with the final reflection focused on development and learning across the semester. This proposal is again suggestive of a simple type of assessed eportfolio - an online document where students can reflect throughout the semester on their skill development during the laboratory (or other) component of the unit, as discussed above.

A small number of students expressed discomfort with the idea of a personal reflection being graded, as if it is personal, it is inappropriate to mark it 'wrong' or 'unsatisfactory'. These concerns could be addressed by providing explicit assessment criteria that make it clear to TAs and students that it is not students' personal views, thoughts, feelings or experiences that are being marked. Such criteria could focus on ensuring that students' reflections show key elements of reflective practice such as being personal, including thoughts and feelings, evaluating and analysing their experiences and identifying learning (Rivera, 2017; Ryan & Ryan, 2015). This may assist some students to feel more comfortable with the reflective task and increase their engagement and benefit.

Additional connections to employability

Whilst the skills badges and reflections were beneficial for the majority of students, there were some students who desired additional or more detailed connections to employment such as descriptions of how the skill is required and applied in relevant jobs and industrial contexts, preferably communicated by someone working in the industry.

> Mak[e] it explicit by having someone come from industry and say yeah, this is how we use pretty much what you're doing in the lab, in our work environment.

For such students, talking about the skills themselves seemed a little vague and lacked sufficient impact in the absence of an applied employment context, with one student even suggesting students should reflect on how they would apply the relevant skill in a targeted role or job type and other students calling for examples of relevant career paths or job-related assignments.

> I think linking what you're doing to specifically what career path that that skill would be involved in; I think that's probably the most useful thing for me when it did happen and when it didn't happen is probably what I was looking for. Like .... which sort of job would I be using this in?

> Is it possible for lecturers to put work from companies in in the form of assignments?

This reflects one of the findings from the research of Nielsen and Holmegaard (2016) amongst physics graduates wherein the graduates found it difficult to identify suitable non-university graduate employment. Like the science students in this study, these physics graduates may have benefited from links to relevant information about or hearing from a range of employers during their course, or provision of some case studies of 'skills in action' in specific employment contexts, to help them make explicit links between the skills they were developing and potential graduate roles.

In the skills badging and curriculum-embedded skills reflection research, many chemistry students also highly valued an authentic industrial context when used to introduce a laboratory task or applied to a laboratory assessment task, with some students expressing that they found the latter more beneficial than the skills badges or reflective task.

Other studies have likewise concluded that students are seeking deep and direct connections between university tasks and employment including advice from employers, those established in the field and recent graduates; industry experiences (such as internships or project work for an industry partner); communication of relevant employment pathways and skill development that is contextualised (George-Williams, Soo, Ziebell, Thompson, & Overton, 2018a; Jorre de St Jorre et al., 2019; Jorre de St Jorre & Oliver, 2018). Whilst the findings from this research suggest that the skills badges and reflections do provide a beneficial explicit connection between university tasks and employment for many students, this and other research also suggests this effect may be enhanced by providing additional connections to employers or the workplace. If academics or other teaching staff share specific examples of how a skill is applied in a relevant real world employment context, or invite employers or graduates to share how the skills are essential and used in such contexts, the impact of the skills badges or reflections may increase through deeply engaging more students and improving their ability to identify and articulate how they will be able to apply their recognised skills in specific employment roles in the future.

8 Conclusions

This research sought to understand whether chemistry and other science undergraduates recognise that they are developing a range of transferable skills during their degree and whether they understand the importance of such skills for employment. Chemistry undergraduates from Monash University and the University of Warwick were able to name an average of three (Monash) or four (Warwick) skills as being developed during their degree, with most students identifying a subset of teamwork, thinking and problem solving, time management, laboratory/practical and communication skills. Some students also named organisational skills and a few identified independent learning or study skills.

Students desired further development of communication, laboratory/practical, time management, thinking and problem-solving skills and skills that would help them find and succeed in employment, such as job application and interview skills, business acumen, workplace related skills, industry and career knowledge and work experience.

The five core skills identified by students as developed remained the same across degree year levels. However, as they progressed through their degree, Monash University students were less likely to identify independent learning skills as developed and to desire the development of independent learning, time management and organisational skills. Monash students were also more likely over time to name higher order skills such as communication, thinking, problem solving or research skills as developed, and laboratory/practical skills as desired for further development and sought by employers. The latter likely reflects that as they progressed through their degree, Monash chemistry students were more likely to have a chemistry career focus. At the University of Warwick, recognition of the development and importance of communication skills increased markedly with year level, whilst desire for further development of thinking and problem-solving skills and discipline knowledge decreased. These Warwick students were completing a chemistry degree in which the focus was on chemistry content and practice in thinking and problem solving, and they were obviously satisfied with the development of these skills. In the Warwick chemistry degree at the time of this study, there was no focus on communication skills until the second year and even then it was limited. Students appeared to recognise that they would need communication skills in the workforce and desired more opportunities during their degree to develop this skill, alongside discipline understanding and skills. The core skills students identified as developed and sought by employers were the same for males and females, although a higher proportion of females than males at Monash recognised the development and importance of teamwork skills and more females at both institutions recognised development of organisational skills.

Students have a much narrower view of skills required in employment than employers and graduates. A reasonable proportion of science students correctly identified that employers are seeking teamwork, communication and thinking and problem-solving skills. However, they failed to recognise that a majority of science employers require laboratory/practical skills and most employers require a wide range of other skills including time management and organisation, interpersonal, computer/IT, numeracy, data analysis, independent learning, leadership, initiative, creativity and innovation, flexibility and adaptability and commercial or business awareness. Whilst some science students did recognise that they were developing teamwork, communication, thinking and problem solving, laboratory/practical and time management skills, most did not recognise development of any of the other skills required by employers or prioritise their development, (which is not surprising, given they had not recognised employers value these skills). Findings from this study also indicated that although students broadly recognise that they are developing thinking and

problem-solving skills during their degree, they find it difficult to recall and articulate specific examples of these skills.

Science students in this study tended to be focused primarily on attaining discipline knowledge and skills and completing curriculum tasks. They were unaware that skill development was a key purpose of many university tasks. Specifying skills as graduate attributes, in unit aims or learning outcomes or including them in assessment tasks, was insufficient to raise students' awareness of a number of employability skills such as numeracy, data analysis, software/IT, research, commercial awareness, creativity or innovation. Many students indicated that they would like academics to communicate the purpose of curriculum tasks as well as the employability skills they could develop from them. These findings strongly support other literature that has called for academics to make explicit links between individual tasks or assessments and the development of transferable skills, by raising or signposting the relevant skills.

Two interventions, displaying transferable skills badges and engaging students in writing skills reflections, were investigated to determine whether they could assist students to better recognise the transferable skills developed during their degree, and to develop the ability to articulate them.

Transferable skills badges were displayed on curriculum materials in several units at Monash University and the University of Warwick. Findings indicated that in the absence of prompting, students are likely to be entirely task and discipline focused and unconscious of transferable skill development. Displaying transferable skill badges on learning resources or assessment tasks enhanced student recognition of specific transferable skills. This was particularly true for skills that were less well recognised by students prior to the badging intervention. Thus, displaying skills badges can help increase students' awareness of the breadth of transferable skills that they are developing in their degree.

Displaying skills badges on curriculum materials provided other benefits for some students including informing them of the skills required in a task (which helped them feel better prepared), communicating a clearer purpose for the task (leading to motivation), providing links between university tasks and 'real life' and identifying examples of transferable skills students could use in job applications and interviews. Overall, many students felt that the skills badges were a positive addition to each unit.

However, students only engaged with and benefited from the badges if they understood their purpose and connection to employment. Not all students understood the purpose of the badges and needed it explicitly explained to them by staff. Students wanted teaching staff to talk more about the badges, link them to tasks and explain and emphasise their importance.

Some TAs did not pay attention to the skills badges but remained focused on discipline content and skills. However other TAs thought the badges were a positive initiative and reported the badges prompted them to talk to students about skills or to adjust their teaching approach to ensure they incorporated the badged skills.

Engaging students in reflection on curriculum-embedded skill development was found to enhance the recognition of the development of some transferable skills. However, even after reflecting, some students found it difficult to identify examples of developing particular skills (including initiative, numeracy or data analysis, adaptability, creativity, professionalism, independent learning, critical thinking and problem solving), and needed prompting from other students or a tutor. Hence, reflection alone is unlikely to result in students identifying the full breadth of available skill development. Displaying skills badges or engaging students in discussion (preferably with the

guidance of a tutor or mentor) is needed to further enhance students' recognition of some skills beyond that obtained from independent reflection, especially when students are inexperienced in reflecting on their skills.

A key benefit of reflection on skill development was that it helped students to articulate their transferable skills as well as to identify examples they could use in job applications and interviews. Reflection on skill development also helped many students to identify skill strengths and weaknesses and opportunities for improvement and to make more sense of their experiences. Thus, including skill reflection as an assessed curriculum task can help overcome the reported weakness of STEM students in articulating their transferable skills in the employment process.

Both displaying skills badges and engaging students in reflecting on their skills helped many students to see a new purpose for curriculum tasks in the development of employability skills. This helped increase the value of the tasks for some students and increased their motivation to complete them.

Students acknowledged that including the reflective task in the curriculum and assigning a grade to it was necessary to provide motivation to complete it, in agreement with evidence from other studies. Some students didn't like writing the in-curriculum skills reflections because they felt disconnected from the rest of the laboratory activity, could be responded to disingenuously, felt that they already recognised their skills, or TA expectations and grading were unclear or inconsistent. As found in the skills badging intervention, some students didn't engage with the reflection task because they didn't understand its purpose and link to employability and needed this clearly explained. Understanding why it's important to be able to articulate their skills and being provided with information on how to reflect were correlated with increased benefits for students from the reflection task. To maximise student engagement and benefit from the reflective task and minimise their frustrations, students requested that staff explicitly communicate the purpose of the task, the grading criteria and the expectations for how the reflections should be structured. TAs requested some training to ensure that they understood this information and how to convey it to students.

Displaying skills badges on curriculum tasks that students were asked to reflect on was seen as helpful by students in the first semester of the second year, but potentially limiting for some more experienced students. For the latter students, the displayed badges were perceived to make the task too easy and tended to restrict reflection to the badged skills, rather than encouraging students to write about the skills most meaningful to their experience. Students and TAs suggested this could be addressed by displaying skills badges in the initial semesters in which students experience reflective tasks, but providing only an overall summary of skills badges in later semesters. It was acknowledged, though, that there was a risk that some students may revert to a narrow or repetitive skill focus under the latter approach.

Students desired a breadth of activities and assessments to be included in the curriculum to enable them to develop the range of skills needed in employment, particularly open-ended tasks that include interaction with others, problem solving and decision-making. However, the findings of this research indicate that students are unlikely to recognise the range of skill development inherent in such tasks unless academics explicitly raise or signpost it. Likewise, it is important to increase students' recognition of the variety of skills they can develop from team-based tasks, beyond teamwork and communication skills, by specifically highlighting them.

Some students were seeking deeper connections to employability beyond skills reflections and badges, including authentic tasks, examples of how skills are applied in specific roles or employment contexts, links to career paths and hearing from employers on these topics.

In summary, the findings of this study indicate that science students are unlikely to be conscious of transferable skill development in the curriculum unless prompted, and when asked, can only name a narrow range of skills as being developed or valued by employers. This confirms prior research that concluded that many STEM students lack the ability to identify and articulate their skills in the employment process and that teaching staff must make explicit links between curriculum tasks, specific skills and the workplace in order for students to connect their learning activities to transferable skill development and employability. This work adds to prior research by identifying which specific skills students are likely to be conscious of in the curriculum and which they need assistance to recognise. It establishes that students' recognition of skills may be enhanced through displaying skills badges on curriculum materials and to an extent through reflection. It also provides evidence that students' ability to articulate skills may be enhanced by engaging students in reflecting on in-curriculum skill development experiences and that both interventions can lead to increased student motivation and engagement. However, communication of the purpose of these initiatives to students is vital if most students are to benefit from them and academics must ensure TAs are asked to communicate this information to students and are provided training in why and how to do so. Students are also more likely to recognise and engage with skill development if teaching staff draw their attention to the skills involved in each task and their importance. This research also provides evidence that many students do value and benefit from employability enhancement initiatives from early in their degree, and are seeking deep and authentic connections between their learning and employment and future career paths.

9 Implications for practice

Since it is clear that science undergraduates do not recognise the breadth of skills they are developing during their degree, educators should explicitly highlight the specific transferable skills students can develop in individual laboratory tasks, workshops, tutorials, research projects, team projects, presentations and other assessment tasks, and explain that such transferable skill development is one of the purposes of these tasks and that these skills are sought by employers. It is particularly important that educators point out to students the opportunities within the curriculum to develop organisation, planning and project management, interpersonal, computer/IT, numeracy, data analysis, critical thinking, problem solving, independent learning and leadership skills, as well as initiative, creativity and innovation, flexibility and adaptability and commercial or business awareness, as students are highly unlikely to recognise development or specific examples of these skills that are so valued by employers. There is also a need to design more learning activities that explicitly develop employer-valued skills such as commercial or business awareness, flexibility and adaptability and creativity or innovation, as there appears to be a lack of opportunities to develop them in the curriculum, as evidenced by this and other studies.

Skills badges should be displayed on curriculum tasks to highlight where students can develop each skill. It is important that a variety of skills badges are used so that a breadth of skills are brought to students' attention and students do not become disengaged due to excessive repetition of the same badges. Priority should be given to highlighting the less recognised skills identified above.

In order to develop students' ability to articulate their skills, educators should include some graded skills reflection tasks in the curriculum, ideally from the second semester of the first year or the beginning of the second year, and continue throughout the degree. Such timing will ensure that students are much better prepared to complete applications for work, volunteering roles and internships that are often due in the middle of the second year, and to apply for graduate roles, the majority of which close early in the third year. However, it is important to acknowledge that there is a workload impact on students and staff from the inclusion of new (reflective) tasks in the curriculum. This may need to be balanced by reducing the number of other curriculum tasks.

Before commencing reflective tasks about skills, students should be provided with an introduction to employability skills, guidance on how to reflect, prompt questions for reflection and clear marking criteria. It is also important to emphasise to students that the reflections do not need to identify new skill development, but can also be used to articulate how a skill was demonstrated or strengthened through repeated practice. Prompt questions should be embedded within the task instructions rather than being provided separately, which some students could miss. Ideally, students should record all of their reflections for a particular unit in an online document such as a simple eportfolio, so that they can monitor their progress across the semester, compile a useful reference resource for the employment process, and reduce repetition. Consideration could be given to linking some reflections directly to employment through a STAR or CAR (or similar) framework that is often used in the recruitment process, and asking students to respond to an interview style question.

When students are asked to initially reflect on their skill development, skills badges should be displayed on relevant tasks, to enhance the breadth of skills on which students are likely to reflect. Late in the second year or in the third year of the degree, when students are more experienced in skill recognition and reflection and should be more challenged, opportunities for reflection using

self-identification of skills could be provided in some tasks, supported by a summary page of skills badges.

In order to ensure that students understand and benefit from the display of skills badges and writing skills reflections, it is very important that academics and TAs explicitly communicate the purpose of these interventions to students and explain how to use them in the employment process. To support these interventions, TAs should be provided with information about transferable skills, be convinced of their importance, be tasked with explaining the purpose of the badges and reflections to students and to briefly draw students' attention to the relevant employability skills at the start of each task.

Finally, student engagement in their learning and their ability to recognise and articulate transferable skill development are likely to be enhanced if additional connections are made between the curriculum and assessment tasks and the workplace and potential careers. Where possible, academics should seek to provide a 'real life' employment context for learning, assessment tasks and skill development; share examples of how skills are applied in potential career pathways and invite employers, established and recent graduates to talk about their required skills and give examples of how they apply them in the workplace.

10 Future research

The research frameworks used in this study could be repeated in other faculties and universities to better understand student recognition of transferable skill development and to evaluate the impact of displaying skills badges, engaging students in skills reflection or other interventions aimed at increasing recognition or articulation of in-curriculum skill development.

Specific avenues for addressing the limitations of this research could include investigating:

- the impact of the skills badges and reflection interventions via a longitudinal study on a single student cohort through a staged approach over several consecutive semesters
- the impact of displaying skills badges on recognition of skill development in more first year and third year units (as only one of each was researched in the current study)
- the impact of engaging students in skills reflection in the curriculum in science disciplines other than chemistry and in first year and third year units
- the impact of engaging students in skills reflection on laboratory research projects (rather than individual laboratory tasks) and on non-laboratory tasks such as team or individual projects
- use of an employment related framework (such as the STAR or CAR approach) and some recruitment style questions for in-curriculum skills reflections
- the impact of engaging late second year or third year students in skills reflection with a skills badges list but without skills badges displayed on individual tasks, after students have experienced skills reflection in the presence of skills badges in earlier semesters

Other avenues for future research regarding enhancing science student skill development, recognition and employability include exploring:

- the impact of awarding digital transferable skills badges to students on completion of relevant curriculum tasks, including awarding badges at two or three different levels (such as 'competent' and 'advanced', or bronze, silver and gold)
- the impact of explicitly assessing and providing feedback on students' transferable skill development. Does this affect their skill recognition, perceived skill development, the value they place on such skills and their motivation to further develop them?
- engaging science students in a laboratory or 'desk' research project based on a brief provided by a specific employer / industry representative, with and without direct engagement with the industry contact. Evaluating the impact of this intervention on students' engagement, skill recognition and development and on their perceptions of skill value, their employability and career intentions and behaviour
- the impact of implementing an eportfolio in a science degree across one or more degree year levels, including the incorporation of skills badges
- the development, communication, application and evaluation of an employability development toolkit for science academics outlining different approaches they might take to enhance students' skills, skill recognition and employability (including skills badges and reflections). This could include simple examples of how to implement each approach and links to evidence of effectiveness
- the development of science undergraduates' professional identity during their degree and its relationship to skill recognition, value and development, career behaviours and the development of personal narratives. Does starting to develop a professional identity

enhance undergraduates' perceived employability and career development behaviours and can such development be enhanced through the curriculum?

- science students' broader employability development across their degree in terms of the Tomlinson (or other) capital model. Identifying which aspects of the degree are perceived to contribute to development of each type of 'employability capital' by students and academics and how this might be enhanced.

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12 Appendices

12.1 Appendix 1: Ethics approval

MONASH University

Monash University Human Research Ethics Committee

Approval Certificate

This is to certify that the project below was considered by the Monash University Human Research Ethics Committee. The Committee was satisfied that the proposal meets the requirements of the *National Statement on Ethical Conduct in Human Research* and has granted approval.

Project Number:	0936
Project Title:	Exploring attitudes to and development of transferable skills amongst Monash Science undergraduates and evaluation of a tool to record & articulate curriculum embedded employability skill development
Chief Investigator:	Professor Tina Overton
Expiry Date:	07/10/2021

Terms of approval - failure to comply with the terms below is in breach of your approval and the *Australian Code for the Responsible Conduct of Research*.

1. The Chief Investigator is responsible for ensuring that permission letters are obtained, if relevant, before any data can occur at the specified organisation.
2. Approval is only valid whilst your hold a position at Monash University.
3. It is responsibility of the Chief Investigator to ensure that all investigators are aware of the terms of approval and to ensure the project is conducted as approved by MUHREC.
4. You should notify MUHREC immediately of any serious or unexpected adverse effects on participants or unforeseen events affecting the ethical acceptability of the project.
5. The Explanatory Statement must be on Monash letterhead and the Monash University complaints clause must include your project number.
6. Amendments to approved projects including changes to personnel must not commence without written approval from MHUREC.
7. Annual Report - continued approval of this project is dependent on the submission of an Annual Report.
8. Final Report - should be provided at the conclusion of the project. MUHREC should be notified if the project is discontinued before the expected completion date.
9. Monitoring - project may be subject to an audit or any other form of monitoring by MUHREC at any time.
10. Retention and storage of data - The Chief Investigator is responsible fo the storage and retention of the original data pertaining to the project for a minimum period of five years.

Thank you for your assistance.

Professor Nip Thomson

Chair, MUHREC

12.2 Appendix 2: Skills survey

Exploring Monash Science undergraduate student skill development

EXPLANATORY STATEMENT

Professor Tina Overton	School of Chemistry	tina.overton@monash.edu
Dr Chris Thompson	School of Chemistry	chris.thompson@monash.edu
Michelle Hill	School of Chemistry	michelle.hill@monash.edu

Please read this Explanatory Statement in full before deciding whether or not to participate in this research. If you would like further information regarding any aspect of this project, you are encouraged to contact the researchers via the email addresses listed above.

What does this research involve?

This research seeks to gain an understanding of the skills desired and currently being developed by Science undergraduates at Monash University. This information will be used to assist in developing and implementing a program to enable undergraduates to record their skill development throughout their undergraduate degree. The aim is to enable undergraduates to better identify and articulate the range of skills gained during their undergraduate degree, to enhance their attractiveness to employers and their ability to find relevant and satisfying employment at the conclusion of their studies.

Why were you chosen for this research?

You were chosen for this research because you are an undergraduate student studying Science at Monash University.

Consenting to participate and withdrawing from the research

Participating in this study is entirely voluntary and you can opt out by simply not completing it. You can also withdraw at any time. It will not affect your undergraduate marks in any way.

Possible benefits and risks to participants

The outcomes from this research should enhance Monash Science graduates' ability to recognise and articulate the skills they have developed and hence enhance their employability. It is not expected to involve any physical or psychological risk to participants.

Confidentiality

This survey is anonymous. No identifying information will be collected. Please don't add your name.

Storage of data

Data storage will adhere to all Monash University regulations. All research surveys will be kept on University premises in a secure locked office and data will be uploaded to a password protected computer. Only the researchers will have access to the data. After five years, the surveys and data will be destroyed securely, adhering to Monash University regulations.

Results

The information collected in the research will be analysed and a report may be submitted for publication in academic journals and as part of a research thesis.

Concerns

If you have any concerns or complaints about the conduct of this project, you are welcome to contact the Executive Officer, Monash University Human Research Ethics Committee (MUHREC), Room 111, Building 3e, Monash University, VIC 3800. Tel: +61 3 9905 2052 Email: muhrec@monash.edu

Exploring Monash Science undergraduate student skill development

1. **What gender do you identify as?**

   O Male O Female O Rather not say

2. **Which of the following are you currently enrolled as?**

   O Local/domestic student O International student

3. **What degree are you currently enrolled in?** (e.g. Science or Science/Engineering etc)

   _____

4. **Your degree year level?** (Please circle) **1st** **2nd**

5. **In addition to developing detailed subject knowledge, what skills do you think you've developed so far during your degree?** (Name up to 5)

*

*

*

*

*

6. **What skills would you like to develop during the remainder of your degree?** (Name up to 5)

*

*

*

*

*

7. **What do you think are the key skills employers are looking for, from graduates?** (Name up to 5)

*

*

*

*

*

12.3 Appendix 3: Skills reflection volunteer program - Pre-program survey

Monash Science Student skill and careers self-assessment #1

1. Date: _____

2. Your name: _____

3. Your student ID number: _____

4. What gender do you identify as?
   - O Female
   - O Male
   - O Rather not say / other

5. Your age group?
   - O 17-21
   - O 22-25
   - O 26-30
   - O Over 30

6. What degree are you enrolled in? (e.g. Science, Science/Engineering, Science/Commerce etc)

   _____

7. What degree year level are you in?
   - O 1st
   - O 2nd
   - O 3rd
   - O 4th
   - O 5th/6th

8. Are you a local or international student?
   - O Local/domestic
   - O International

9. What language do you speak at home?
   - O English
   - O Other: _____

10. What units are you enrolled in this semester?
    - *
    - *
    - *
    - *

11. What's your degree major (if you've chosen one so far)?

_____

12. Please rate your current skill level in each of the following areas

(Please tick one response column in each row)

Note that "Excellent" does not imply perfection (as it is always possible to improve), but indicates a really high level of expertise or mastery of this skill

	1 Non-existent	2 Very Limited	3 Limited	4 Moderate	5 Good	6 Very good	7 Excellent
Planning, organisation and time management							
Creativity & Innovation							
Adaptability / flexibility							
Teamwork skills							
Ability to use own initiative							
Written communication							
Report writing skills							
Verbal communication							
Presentation skills							
Computer/technology/IT skills							
Problem-solving skills							
Analytical / Critical thinking skills							
Professionalism							
Laboratory/practical skills							
Leadership skills							
Quantitative/maths/data analysis skills							
Research skills - planning & designing experiments							
Research skills – locating & retrieving information							
Independent learning skills							
Industry / business awareness							
Intercultural competence							
Ethical awareness & behaviour							

13. Which of the following further education opportunities are you interested in or considering (after completing your bachelor degree)? *(Please tick all that apply)*

- O Honours (it is already a compulsory aspect of my degree)
- O Honours (it is not compulsory in my degree)
- O Masters
- O PhD
- O None of the above

14. Which of the following career directions are you considering or might you consider? *(please tick as many as apply)*

- O Research and/or teaching at a university (academic role)
- O Teaching (primary or secondary school) or other education sector role
- O Information Technology (IT) or computer science industry role
- O Science, engineering or other technology industry role
- O Medical or health industry role
- O Graduate job in a Government department
- O Graduate job in a non-Science industry or organisation (e.g. business, banking/finance, insurance, marketing/PR/advertising, journalism, sports, legal, HR, retail, trade etc)
- O Not sure at the moment

15. Please tick to what extent you agree or disagree with each of the following statements:

	Strongly disagree	Disagree to some extent	Neither agree or disagree	Agree to some extent	Strongly agree
I am satisfied with the course/degree I'm doing					
The overall quality of my course/degree is very good					
I am motivated to complete my degree					
It is important to start preparing now for a job/career					
I am confident in my ability to prepare high quality applications for graduate jobs					
I feel confident in my ability to interview well for a graduate job					
I am confident of success in job interviews					
The skills I am developing at university are useful					
The skills I am developing at university are what employers are looking for					
I will need to further develop some skills in order to be ready for the work place					
I will need to further develop some skills in order to be successful at gaining a graduate job					

16. In your opinion, what is the best stage of university to start actively preparing for a job/career? *(please place a tick underneath your chosen response)*

First year	Second year 1st semester	Second year 2nd semester	Third year 1st semester	Third year 2nd semester	1st semester of final year (if your degree is > 3 years)	2nd semester of final year (if your degree is > 3 years)	Other (please specify when)

17. Are there any other comments you'd like to make about your skills or career ideas or preparations?

12.4 Appendix 4: Skills reflection volunteer program - Post-program survey

Monash Science Student skill and careers self-assessment #2

1. Date: _____

2. Your student ID number: _____

3. **Please rate your current skill level in each of the following areas**
   (Please tick one response column in each row)
   Note that "Excellent" does not imply perfection (as it is always possible to improve), but indicates a really high level of expertise or mastery of this skill

	1 Non-existent	2 Very Limited	3 Limited	4 Moderate	5 Good	6 Very good	7 Excellent
Planning, organisation and time management							
Creativity & Innovation							
Adaptability / flexibility							
Teamwork skills							
Ability to use own initiative							
Written communication							
Report writing skills							
Verbal communication skills							
Presentation skills							
Computer/technology/IT skills							
Problem-solving skills							
Analytical / Critical thinking skills							
Professionalism							
Laboratory/practical skills							
Leadership skills							
Quantitative/maths/data analysis skills							
Research skills - planning & designing experiments							
Research skills – locating & retrieving information							
Independent learning skills							
Industry / business awareness							
Intercultural competence							
Ethical awareness & behaviour							

5. To what degree do you think you have you improved each of the following skills during the current semester (that is just about to finish), as a result of your university course/units?

	Degree of skill improvement over the semester:			
	None	A little	Some	A lot
Planning, organisation and time management				
Creativity & Innovation				
Adaptability / flexibility				
Teamwork skills				
Ability to use own initiative				
Written communication				
Report writing skills				
Verbal communication skills				
Presentation skills				
Computer/technology/IT skills				
Problem-solving skills				
Analytical / Critical thinking skills				
Professionalism				
Laboratory/practical skills				
Leadership skills				
Quantitative/maths/data analysis skills				
Research skills - planning & designing experiments				
Research skills – locating & retrieving information				
Independent learning skills				
Intercultural competence				
Industry / business awareness				
Ethical awareness & behaviour				

6. Which of the following career directions are you considering or might you consider? *(please tick as many as apply)*
   - O Research and/or teaching at a university (academic role)
   - O Teaching (primary or secondary school) or other education sector role
   - O Information Technology (IT) or computer science industry role
   - O Science, engineering or other technology industry role
   - O Medical or health industry role
   - O Graduate job in a Government department
   - O Graduate job in a non-Science industry or organisation (e.g. business, banking/finance, insurance, marketing/PR/advertising, journalism, sports, legal, HR, retail, trade etc)
   - O Not sure at the moment

7. Which of the following further education opportunities are you interested in or considering (after completing your bachelor degree)? *(Please tick all that apply)*
   - O Honours (it is already a compulsory aspect of my degree)
   - O Honours (it is not compulsory in my degree)
   - O Masters
   - O PhD
   - O None of the above

8. Please tick to what extent you agree or disagree with each of the following statements:

	Strongly disagree	Disagree to some extent	Neither agree or disagree	Agree to some extent	Strongly agree
I am satisfied with the course/degree I'm doing					
The overall quality of my course/degree is very good					
I am motivated to complete my degree					
It is important to start preparing now for a job/career					
I am confident in my ability to prepare high quality applications for graduate jobs					
I feel confident in my ability to interview well for a graduate job					
I am confident of success in job interviews					
The skills I am developing at university are useful					
The skills I am developing at university are what employers are looking for					
I will need to further develop some skills in order to be ready for the work place					
I will need to further develop some skills in order to be successful at gaining a graduate job					

9. In your opinion, what is the best stage of university to start actively preparing for a job/career? *(please place a tick underneath your chosen response)*

First year	Second year 1st semester	Second year 2nd semester	Third year 1st semester	Third year 2nd semester	1st semester of final year (if your degree is > 3 years)	2nd semester of final year (if your degree is > 3 years)	Other (please specify when)

10. To what extent has participation in skills recording and reflection helped you do the following:

	Skills recording and reflection has helped me:			
	Not at all	A little	To some extent	A lot
Identify my skill strengths				
Identify skills that need improvement or more development				
Make more sense of my experiences				
Gain more value from my degree units				
Become more motivated about career planning				
Develop examples I can use in my CV				
Develop examples I can use in job interviews				
Develop skills that will help me present myself more effectively in job interviews				
Start preparing for the job hunting and application process				
Become more motivated about my studies				
Feel more satisfied with some course units				

11. Is there anything else you'd like to add about your skills or your involvement in skills reflection, or any other aspect of job or career planning?

12.5 Appendix 5: Skills badging intervention - Pre-badging survey

Science Undergraduate Skills Survey – CHM2911 "Inorganic & Organic Chemistry"

1. What gender do you identify as?
   O Female O Male O Other / Rather not say

2. What is your age group?
   O 17-21 O 22-25 O 26-30 O Over 30

3. What degree are you enrolled in? (Science, Science/Engineering, Science/Commerce etc)
   _____

4. What degree year level are you in?
   O 1st O 2nd O 3rd O 4th O 5th or 6th

5. Are you a local or international student?
   O Local/domestic O International

6. What language do you speak at home?
   O English O Other: _____

7. What's your degree major (if you've chosen one so far)?
   _____

8. To what extent do you think CHM2911 provided an opportunity to develop each of these skills?

	Opportunity to develop this skill provided by CHM2911:			
	None	A little	Some	A lot
Organisation and time management				
Literature research skills				
Adaptability / flexibility				
Teamwork skills				
Ability to use own initiative				
Report writing skills				
Written communication skills e.g. email, letters, applications etc				
Verbal communication skills				
Presentation skills				
Computer/technology skills				
Problem-solving skills				
Analytical / Critical thinking skills				
Experiment design skills				
Leadership skills (leading others)				
Numeracy/quantitative/maths skills				
Independent learning skills				
Commercial / business awareness				
Ethical awareness & behaviour				

9. Is there anything else you'd like to add about the skill development opportunities offered by unit CHM2911, or CHM2911 in general?

10. Which of the following career directions are you considering or might you consider? *(please tick as many as apply)*
    - O Research and/or teaching at a university (academic role)
    - O Science, engineering or other technology industry role
    - O Teaching (primary or secondary school) or other education sector role
    - O Information Technology (IT) or computer science industry role
    - O Medical or health industry role
    - O Graduate job in a Government department
    - O Graduate job in a non-Science industry or organisation (e.g. business, banking/finance, insurance, marketing/PR/advertising, journalism, sports, legal, HR, retail, trade etc)
    - O Other. Please specify: _____
    - O Not sure at the moment

11. How important do you think each of these skills are likely to be in helping you obtain a job and succeed at it, after you graduate?

	Importance for your future job/career				
	Not important	Slightly important	Fairly important	Very important	Extremely important
Organisation and time management					
Literature research skills					
Adaptability / flexibility					
Teamwork skills					
Ability to use own initiative					
Report writing skills					
Written communication skills e.g. email, letters, applications etc					
Verbal communication skills					
Presentation skills					
Computer/technology skills					
Problem-solving skills					
Analytical / Critical thinking skills					
Experiment design skills					
Leadership skills					
Numeracy/quantitative/maths skills					
Independent learning skills					
Commercial / business awareness					
Ethical awareness & behaviour					

12. Are there any other skills you think will be important in helping you obtain a job, or anything else you'd like to add about skills and job preparation in general?

12.6 Appendix 6: Skills badging intervention - Post-badging survey

Science Undergraduate Skills Survey – CHM2911 "Inorganic and organic chemistry"

1. What gender do you identify as?

   O Female O Male O Other / Rather not say

2. What is your age group?

   O 17-21 O 22-25 O 26-30 O Over 30

3. What degree are you enrolled in? (Science, Science/Engineering, Science/Commerce etc)

   _____

4. What degree year level are you in?

   O 1st O 2nd O 3rd O 4th O 5th or 6th

5. Are you a local or international student?

   O Local/domestic O International

6. What language do you speak at home?

   O English O Other: _____

7. What's your degree major (if you've chosen one so far)?

   _____

8. To what extent do you think CHM2911 provided an opportunity to develop each of these skills?

	Opportunity to develop this skill provided by CHM2911:			
	None	A little	Some	A lot
Organisation and time management				
Literature research skills				
Adaptability / flexibility				
Teamwork skills				
Ability to use own initiative				
Report writing skills				
Written communication skills e.g. email, letters, applications etc				
Verbal communication skills				
Presentation skills				
Computer/technology skills				
Creativity				
Problem-solving skills				
Analytical / Critical thinking skills				
Experiment design skills				
Leadership skills (leading others)				
Numeracy/quantitative/maths skills				
Independent learning skills				
Commercial / business awareness				
Ethical awareness & behaviour				

9. For the skill opportunities you recognised above, on average, **to what extent were you aware at the time you were doing CHM2911**, that you had the opportunity to develop these skills?

Not aware	Slightly aware	Fairly aware	Very aware

10. Is there anything else you'd like to add about the skill development opportunities offered by CHM2911, or CHM2911 in general?

11. Which of the following career directions are you considering or might you consider? *(please tick as many as apply)*
    - O Research and/or teaching at a university (academic role)
    - O Science, engineering or other technology industry role
    - O Teaching (primary or secondary school) or other education sector role
    - O Information Technology (IT) or computer science industry role
    - O Medical or health industry role
    - O Graduate job in a Government department
    - O Graduate job in a non-Science industry or organisation (e.g. business, banking/finance, insurance, marketing/PR/advertising, journalism, sports, legal, HR, retail, trade etc)
    - O Other. Please specify: _____
    - O Not sure at the moment

12. How important do you think each of these skills are likely to be in helping you obtain a job and succeed at it, after you graduate?

	Importance for your future job/career				
	Not important	Slightly important	Fairly important	Very important	Extremely important
Organisation and time management					
Literature research skills					
Adaptability / flexibility					
Teamwork skills					
Ability to use own initiative					
Report writing skills					
Written communication skills e.g. email, letters, applications etc					
Verbal communication skills					
Presentation skills					
Computer/technology skills					
Creativity					
Problem-solving skills					
Analytical / Critical thinking skills					
Experiment design skills					
Leadership skills					
Numeracy/quantitative/maths skills					
Independent learning skills					
Commercial / business awareness					
Ethical awareness & behaviour					

13. Are there any other skills you think will be important in helping you obtain a job, or anything else you'd like to add about skills and job preparation in general?

(Continued over the page)

14. How often did you notice skills badges on CHM2911 course materials this semester?

Never	Occasionally	Sometimes	Fairly often	Frequently

15. Please tick to what extent you agree or disagree with the following statements:

Displaying skills badges on CHM2911 materials …….	Strongly disagree	Disagree to some extent	Neither agree or disagree	Agree to some extent	Strongly agree
prompted me to think about skills, not only the course content					
made no difference to me					
was a positive addition to the unit					
helped me to recognise some skills I could gain from this unit					
wasn't meaningful to me – I wasn't sure what they meant or why they were there					
was unhelpful because it distracted me from the content / tasks for the unit					
increased the value I saw in this unit					

16. Do you have any other comments about the skills badges displayed on CHM2911 course materials this semester?

12.7 Appendix 7: Skills badging & reflection intervention - Post-intervention survey

Science Undergraduate Skills Survey – Unit XXXX

1. What gender do you identify as?

   O Female O Male O Other / Rather not say

2. What is your age group?

   O 17-21 O 22-25 O 26-30 O Over 30

3. What degree are you enrolled in? (Science, Science/Engineering, Science/Arts etc)

   _____

4. What degree year level are you in?

   O 1st O 2nd O 3rd O 4th O 5th or 6th

5. Are you a local or international student?

   O Local/domestic O International

6. What's your degree major? _____

7. To what extent do you think Unit XXXX provided an opportunity to develop each of these skills?

	Opportunity to develop this skill provided by Unit XXXX:			
	None	A little	Some	A lot
Organisation and time management				
Literature research skills				
Adaptability / flexibility				
Teamwork skills				
Ability to use own initiative				
Report writing skills				
Written communication skills e.g. email, letters, applications etc				
Verbal communication skills				
Presentation skills				
Computer/technology skills				
Problem-solving skills				
Analytical / Critical thinking skills				
Experiment design skills				
Leadership skills (leading others)				
Numeracy/quantitative/maths skills				
Independent learning skills				
Commercial / business awareness				
Ethical awareness & behaviour				
Creativity				

8. Is there anything else you'd like to add about the skill development opportunities offered by Unit XXXX?

9. **How often did you notice skills badges** on Unit XXXX course materials this semester?

Never	Occasionally	Sometimes	Fairly often	Frequently

10. Please tick to what extent you agree or disagree with the following statements:

Displaying skills badges on Unit XXXX materials …….	Strongly disagree	Disagree to some extent	Neither agree or disagree	Agree to some extent	Strongly agree
helped me to recognise some skills I could gain from this unit					
made no difference to me					
was a positive addition to the unit					
prompted me to think about skills, not only the course content					
wasn't meaningful to me – I wasn't sure what they meant or why they were there					
was unhelpful because it distracted me from the content / tasks for the unit					
increased the value I saw in this unit					

11. Many of the Unit XXXX lab reports included writing a short reflection on an employability skill you had used or developed in that lab. To what extent do you agree or disagree with the following statements about writing these skill reflections and other related statements?

	Strongly disagree	Disagree to some extent	Neither agree or disagree	Agree to some extent	Strongly agree
I liked writing reflections about my skills					
Writing skills reflections was difficult					
It was easy to identify a skill to write about					
Writing skills reflections got easier as I did more of them					
I knew where to find help with writing skills reflections if I needed it					
My TA explained the purpose of writing skills reflections					
I understand why it's important to be able to write and talk about my employability skills					
It is important to start preparing now for a job/career					
All that matters right now is completing my degree units and doing well in assessments. I'll worry about a job/career later.					

12. To what extent did writing skills reflections help you do the following:

	Writing skills reflections helped me:			
	Not at all	A little	To some extent	A lot
identify some skills I have developed				
identify some skills I could improve				
think about skills, not only the unit content				
make more sense of my experiences				
develop my ability to express my skills in words				
identify some examples of my skills I could use in job applications or interviews				
get more out of this unit				

13. Do you have any other comments about writing skills reflections, skills badges or any other aspect of Unit XXXX?

12.8 Appendix 8: Examples of skills badges displayed in curriculum tasks

CHM2962 LABORATORY MANUAL - EXERCISE 3

BEEUTIFUL PRODUCTS™ CONSULTANCY PROJECT: DETERMINATION OF HYDROXYMETHYLFURFURAL (HMF) IN HONEY AND GOLDEN SYRUP

LEARNING OUTCOMES

After completing this exercise you will be able to:

- measure the visible spectrum for an HMF containing honey sample
- quantify relative quantities of this impurities in different samples.
- generate a scientific report which also serves a non-scientific audience.

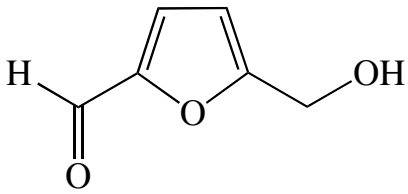
Commercial awareness

Numeracy

Independence & initiative

INTRODUCTION

Hydroxymethylfurfuryl (HMF), right, is one of the reaction products that occurs when sugars are heated and is thus present in honey that has been heated, and is also found in commercial invert sugar (golden syrup). Honey which has been surreptitiously diluted with golden syrup is often exposed through analysing the HMF concentration.



Nevertheless, small amounts of HMF naturally occur in honey stored at room temperature, at approximately 50ppm (50 mg/kg). The HMF content of honey will rise with time at ca 10 mg/kg per month and so can also be used to determine the age of the honey.

HMF has a distinctive chromophore with λ_{max} = 284 nm. Upon the reaction between bisulphite and the aldehyde group, this chromophore disappears. Thus the Beer-Lambert Law can be used with the well established molecular absorption coefficient for HMF, ε = 16830 $mol^{-1}Lcm^{-1}$, to determine the concentration in solution.

CONTEXT

Commercial awareness

Beeutiful Products™ has approached the School of Chemistry to complete an analysis of three Australian honey products, two from cooler Victorian climates, and one using honey sourced from northern Queensland, for HMF content. The company reputation is recovering from an embarrassing discovery that their products had been diluted with golden syrup. Several new products are planned for release, and a strict upper limit of 40 mg/kg has been proposed for HMF concentrations.

The following CHM2962 activity will be used to crowd-source experimental data for the three new products, alongside a standard golden syrup, for reporting back to the company.

IMPORTANT NOTES

- Use only clean glassware.
- Take care not to contaminate solutions.
- Do not use the same pipette for more than one solution.
- Ensure that all the sticky solutions are thoroughly cleaned up.

REAGENTS AND APPARATUS

➢ Carrez solution I: $K_4Fe(CN)_6.3H_2O$ (aq) ~ 0.35 M	➢ $NaHSO_3$ (aq) ~ 0.015 M
	➢ UV/Vis spectrophotometer
➢ Carrez solution II: $Zn(CH_3CO_2)_2$ ~ 2.0 M	➢ Quartz absorption cells
	➢ Honey Samples 1-3 & golden syrup

PROCEDURE

a) Experimental Design

Independence & initiative

In groups of 2 (or 3) analyse the three honey samples and the golden syrup sample provided. You will not be provided with a detailed procedure, and your group will be expected to design the experiment using the information in parts b) and c) below. Prepare a flow chart for your experimental design. This needs to be authorised by your demonstrator before commencing the experiment.

b) Sample Preparation

The following points should guide you:

- Prepare your samples in 50 mL volumetric flasks.
- Use approximately 5 g honey / golden syrup for each sample, weighed accurately to within +/- 1 mg.
- (You will need to consider the best method for quantitatively transferring the sample to the flask!)
- Each flask should contain 1 % Carrez Solution I
- Each flask should contain 1 % Carrez Solution II
- A drop of alcohol may be added after you have diluted to the 50 mL mark to suppress any surface foam that may have formed.

**Your report should comment on your observations at this point. Provide an explanation for what you have observed.*

c) UV/vis Spectrophotometry Measurements

i) It is essential that you use a clear solution for the spectrophotometry measurements. Your demonstrator will show you how to use the centrifuge in the laboratory to ensure this is the case. Your solution will need to be transferred to a centrifuge tube. A setting of 2500 rpm is recommended.

ii) The spectrophotometry measurements are made in comparison to a reference solution, where the absorbance is suppressed. Thus, a reading must be taken for the reference, followed by the sample. Prepare your solutions in large test tubes using the information in the table below.

Reference	Sample
5 mL sample	5 mL sample
5 mL 0.2 % $NaHSO_3$	5 mL deionised water

The vortex mixer should be used to ensure good mixing.

*Your final report should include an explanation of the chemistry in the reference samples.

The spectrophotometry measurements in this experiment must be done using quartz cuvettes, as opposed to the plastic variety often used.

- Make your measurements at λ_{max} = 284 nm, where ε = 16830 $mol^{-1}Lcm^{-1}$.
- Zero the spectrometer before <u>every</u> measurement using water.
- If the absorbance is too high (> 0.6), dilute and re-measure.
- Empty and reload the cuvette to take triplicate results for each sample.

CALCULATIONS

Numeracy

The concentration of HMF in each sample can be determined using the Beer-Lambert Law:

$$\text{Absorbance (A)} = \varepsilon \times C \times l$$

where ε is extinction coefficient, mol^{-1} L cm^{-1}, C is the concentration (molarity), mol L^{-1} and l is the path length, cm.

Your prelab activity demonstrated how these calculations are done. Revisit this on Moodle if you are unsure how to proceed.

**You must account for any dilution factors used during sample preparation.*

In this case present your final value as HMF concentration in honey (mg/kg).

PREPARING YOUR FINAL REPORT FOR BEEUTIFUL PRODUCTS™.

Introduction (~250 words):

- This is a scientific report, however it should include an introduction for non-science experts. The readers will include the Board of Directors at Beeutiful Products™, who do not have a science background.
- Describe the aim of the experiment.

Method:

- Provide your detailed method including a flow chart.
- In your method comment on the importance of adding the Carrez Solutions, and the centrifuging step.

Results:

- Determine the HMF content of the honey samples 1, 2 & 3, and the golden syrup.
- Demonstrate how you have made the calculations.
- As well as including these values in your report, they need to be entered into the Google Spreadsheet via Moodle.

Discussion (Scientific Audience):

- Comment on any errors in your measurements.

- Were there any approximations or estimations made in your method?

Conclusions (Non-scientific Audience):

Commercial awareness

- Your conclusion needs to be written for the Beeutiful Products™ executives.

SCI2010 Workshop 8: The peer-review process

Workshop preparation

- Attend the second two lectures on scientific ethics.
- Reading:

  McKarney L (2001) Peer review techniques for novices. Science Career Magazine.

  http://sciencecareers.sciencemag.org/career_magazine/previous_issues/articles/2001_04_20/nodoi.504563123681812105 7

- Revise "Tips for writing a great literature review".
- Bring: A draft of your literature review to this workshop (this is Assignment 1c).

Workshop aims and objectives

The aims of this workshop are (a) for you to appreciate the importance of peer review in the scientific process; and (b) to get valuable feedback on your literature review draft. On completion of this workshop, you should be able to:

- Explain what is meant by 'peer review' and how the process is used in science;
- Review and give constructive feedback on a peer's work.

Employability skills:

Workshop activities

Activity 1: Reviewing reviews;

Activity 2: Peer reviewing/proofreading a draft literature review.

Workshop output

- You will proofread another student's literature review draft and provide feedback.
- Your own draft will be proofread.

Thinking & problem-solving

Activity 1: Good and bad reviews

In the workshop 8 folder on Moodle you will find a complete review for a primary scientific article submitted to the Journal of Experimental Zoology Part A. You will notice the review includes comments from the editor in chief, the associate editor and two independent referees. The comments made by reviewer #1 and reviewer #2 provide a good example of the variation that you can receive.

Read the referee reviews and highlight the comments that you would consider good, and those you would consider to be less useful.

Were the referees constructive? Describe their style.

Activity 2: Peer-review/proofread a draft/plan literature review

Independence & initiative

How to perform a peer review

1. Using the peer review form available in class: Swap literature review drafts/plans with someone else in class.

2. Start by reading it straight through without taking any notes. As you are reading, think about what the major research question & scope are.
3. Now, try to clearly write what the major research question & scope are in the space provided on the peer-review form.
4. Read through the work again and address each of the points in the peer-review form. Write additional comments and suggestions in the space provided. You may also write comments directly on the reviews themselves.
5. Specific points to consider are listed under the headings 'Content', 'Structure', 'Style' and 'References'.
6. Remember, your review will be used by someone to improve their final literature review so make sure you are constructive!
7. You should also use this experience to think about how you can improve your own literature review.
8. At the end of this activity, you will need to show your peer-review form, along with the literature review plan, to your tutor.

Written communication

Thinking & problem-solving

Use of tools, technology & software

Numeracy

Thinking & problem-solving

Independence & initiative

University of Warwick
Year 1 Main Lab 3 (M3): Bromination of an Alkene

Background Information

Bromine and chlorine both react readily with alkenes to yield 1,2-dihaloalkanes in a process known as electrophilic addition. For example, more than 5 million tons per year of 1,2-dichloroethane are synthesised industrially by the addition of chlorine to ethene. The products are valuable as a solvent and a starting material for the manufacture of poly(vinyl chloride), PVC.

The addition of bromine also serves as a simple and rapid test for unsaturation. A sample of unknown structure is dissolved in an inert solvent and placed in a test-tube to which several drops of bromine are added. Immediate disappearance of the reddish bromine colour signals a positive test and indicates that the sample is likely to be an alkene or alkyne.

The addition of iodine across double bonds occurs in a similar fashion and has been used as a test to determine the level of unsaturation in fats and oils.

During this experiment you will brominate (*E*)-1,2-Diphenylethene (*trans*-stilbene). You will determine the optimum solvent required to purify the product by recrystallisation and will identify which stereoisomer(s) you have made.

("Organic Chemistry", Clayden, Greeves, Warren and Wothers, Chapter 19).

Practical Techniques

You will carry out the following practical techniques during the experiment:

- Measurement of masses
- Reflux
- Choosing a recrystallisation solvent
- Recrystallisation

Safety Information

DO ALL EXPERIMENTAL WORK IN THE FUME CUPBOARDS. WEAR SAFETY SPECTACLES AND LAB COATS AT ALL TIMES

Methanol, ethyl acetate, ethanol, toluene: Highly flammable solvents with toxic vapours. Use in the fume cupboard **AT ALL TIMES.**

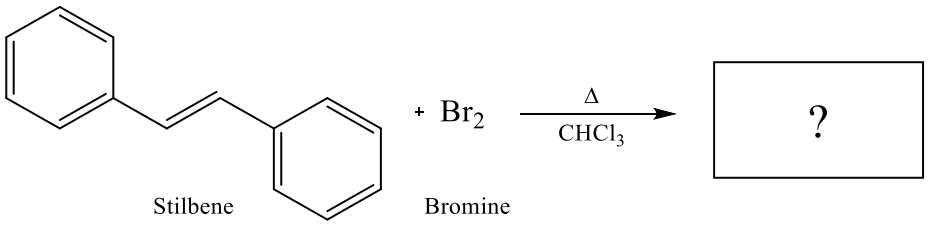
Chloroform: Toxic, do not breath vapours. Avoid skin contact. Wear gloves.

Bromine 1 M in chloroform: Toxic, corrosive, liberates highly toxic vapours. Use in fume cupboard. Wear gloves at all times.

Stilbene: Irritant. Toxic to aquatic life, place all washing in appropriate waste container. Do not wash down the sink.

Year 1 M3: Bromination of an Alkene

Experimental Method



Calculate the mass of 0.005 moles of the alkene (*trans*-stilbene, formula weight 180.25 $gmol^{-1}$). 1 mole equivalent of bromine solution relative to the alkene is needed; hence calculate the volume of 1M bromine solution required.

To a 100 cm^3 round bottom flask, add 0.005 moles of the alkene, followed by 5 cm^3 of chloroform. Add one mole equivalent of bromine (from the 1M bromine (Br_2) in chloroform supplied) to the flask and a small stirrer bar. Using a heating block on the hot plate, heat the mixture under gentle reflux conditions (at 85-90 °C) until no further colour changes are evident. The reaction normally takes about 45 minutes to reach completion at this temperature, so this is a suitable time for a lunch break.

Allow the solution to cool to room temperature, then cool on ice. Isolate the crystals that form via suction filtration in a Hirsch funnel.

Recrystallisation of the product.

Finding the most suitable solvent for recrystallisation is often a tricky and lengthy exercise. Discuss with your demonstrator before starting the procedure.

Perform test recrystallisations of the product in ethyl acetate, ethanol, and toluene and chloroform using **small** volumes of solvent in a test-tube. Using too much solvent or too much product will affect your results. Check with your demonstrator for guidance on appropriate quantities if you are unsure.

Tabulate the results in the following format, noting how much solid and solvent were used

Solvent	Does the dibromide dissolve in COLD solvent?	Does the dibromide dissolve in HOT solvent?	Do crystals form on cooling on ice?
Ethyl acetate			
Ethanol			
Toluene			
Chloroform			

Remember, the optimal solvent will have a limited or zero solubility of the product in cold solvent, but high solubility of the product in hot/ boiling solvent.

Recrystallise the product from the most suitable solvent that you have found. Collect the crystals via suction filtration using a Hirsch funnel and pump to dryness.

Record the appearance, yield and melting point of your product in your lab book, and take an IR spectrum. You should calculate your percentage yield and assign the peaks of your IR spectrum BEFORE YOU LEAVE THE LAB. Your annotated IR spectrum should be submitted online as part of your post lab assignment.

When you have finished make sure all your glassware has been washed, dried and put away. Used solvents must be poured into the correct waste solvent container.

12.9 Appendix 9: Introductory page to skills badges in a laboratory manual

Employability skills and CHM2962

As well as enhancing your knowledge of food chemistry, this unit will offer you the opportunity to further develop skills that will increase your employability i.e. your ability to gain a job when you graduate and succeed in the workplace.

These employability skills are skills employers are looking for from graduates (and other employees) in addition to a degree or qualification. Extensive research has shown employers are seeking communication skills (written and verbal), thinking skills, problem-solving skills, initiative, independent learning skills, adaptability and flexibility, teamwork/collaboration skills, computer/technology/software skills, creativity and numeracy. If you are interested in learning more about what employers are looking for, or how to further build, record or communicate your employability skills, see the references below.

It is really important you recognise the employability skills you are developing, so you can highlight them in job applications and interviews, and give examples of how you have developed and used them.

Whenever a task or assessment in CHM2962 offers you an opportunity to develop an employability skill, you will see the relevant skills badge/icon as shown below:

Helpful sites and references on employability skills:

https://www.monash.edu/career-connect/jobs/employability/employability-skills
https://www.monash.edu/student-futures
https://www.monash.edu/students/leadership/leap/online

Deloitte Access Economics. (2014). *Australia's STEM workforce: a survey of employers*. Australia: Australian Government, Office of the Chief Scientist

Sarkar, M., Overton, T., Thompson, C., & Rayner, G. (2016). Graduate Employability: Views of Recent Science Graduates and Employers. *International Journal of Innovation in Science and Mathematics Education, 24*(3), 31-48.

12.10 Appendix 10: Student guide to reflecting on employability skills

A student guide to reflective writing on employability (transferable) skills

What is reflection & what are the benefits?

Reflection is the process of thinking about and analysing our experiences to capture meaning and learning from them.

Having experiences doesn't necessarily lead to any learning. "Reflection turns experience into learning…and enables learners to gain the maximum benefit from situations they find themselves in." (Boud, Keogh & Walker 2013)

Skills reflection focuses on identifying the skills needed in a particular situation and how you are learning about, developing and using those skills and what you can do to further improve them.

The benefits of reflecting on your skills include:

- recognising your skill strengths and weaknesses
- identifying ways you can further improve your skills
- identifying what you're already doing well so you can consciously continue that behaviour and approach
- identifying and recording specific examples of your skills that you can share in job applications and interviews
- remembering examples of your skills
- recognising your progress over time and gaining confidence in the range of skills you're developing
- improving your communication and thinking skills
- creating a habit you can continue to use during future study, research experiences and in the workplace, to further develop and improve yourself

How to reflect

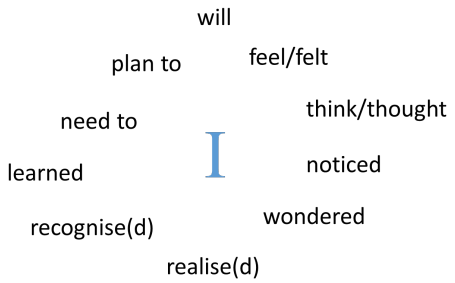
- Use the first person – "I"
- Write about personal development not subject/discipline knowledge
- Include thoughts & feelings
- Be honest
- Identify what went well and what didn't
- Think about how this experience relates to your previous ideas or experiences
- Think about what you have learned
- Identify one or two key points to take forward for the future – what next?

Prompt questions to help you reflect:

These are a guide. You do not have to respond to all these questions in every skills reflection, but #2* is essential.

1. What happened? What did you do?
2. Which skill(s) did you need, use, develop, work on and/or learn about?*
3. Did you face any difficulties or challenges? If so, how did you approach them?
4. How did you feel?
5. What went well or what didn't go well? What could you have done better?
6. What have you learned?
7. What will you do in the future? Is there something you would do again? Is there something you would do differently next time?

Some useful words for reflecting:



References – where to get further help or ideas on skills reflection

In the manual, each lab exercise shows some specific skills badges. You could reflect on one of the badged skills, but you don't have to. For an overall list of skills you could reflect on, see:

- Page 9 of CHM2911 lab manual
- https://www.monash.edu/career-connect/jobs/employability/employability-skills
- https://www.monash.edu/student-futures

Other employability skills/qualities you could consider reflecting on include:
Written communication, resilience, interpersonal skills, attention to detail, adaptability/flexibility

For more ideas about words & phrases that can be useful when reflecting, see:

- www.alia.org.au/sites/default/files/documents/Reflective%20Practice%20Vocabulary%20Aid.pdf

Boud, D., Keogh, R., & Walker, D. (2013). *Reflection: Turning experience into learning*

Examples of skills reflections

Example 1 - Poor

This experiment identified the importance of precision (number of drops) in relation to performing well rounded experiments and obtaining reliable results and observations. Transition metals react in an assortment of ways to produce varying colours and precipitates. This experiment could possibly have been better performed in pairs, so that the working stations were less crowded.

This is a poor example of personal skills reflection as it focuses on the practicalities of doing the experiment and on the underlying chemistry. It is not personal (does not use 'I') and doesn't directly identify or personally reflect on any specific employability skills the student used / developed.

Example 2 - Good

Today's laboratory practical highlighted many new skills and practices for myself. In terms of skills there are many improvements still to be made such as in my written communication skills in the laboratory. I need to be more clear and concise in my recorded observations as sometimes I try to state too much and forget to make obvious my intention in the observation. Also, I had to work in a team and I found this quite challenging. I quite like to get on on my own, so accommodating others was difficult and I think I became quite frustrated. This has highlighted something I need work on - improving my teamwork skills in the future. Overall, this was a challenging session for me but I look forward to improving over the semester.

This is much better. The student identifies two skills needed in this laboratory exercise and reflects on their personal development of each skill, how they felt and how they can improve.

Example 3 - Good

Because I had been really worried about the lab I decided to take some advice from a friend and organise myself in advance, by spending quite a bit more time preparing. I didn't really think it would work that well because I thought if I don't understand it in the lab how will I understand it before the lab. But it freed up quite a bit of time because I had already looked up some words that I couldn't remember from last semester and I had written a draft of my aim which saved me time. I wrote it in pencil so once I knew which bits were correct I just filled it out in pen and didn't have to think about it anymore. I think I'll try to do this in the future because I'll have more confidence I can get through everything in the time I have. Planning and preparing for this experiment in this way showed me the benefit of having good organisation skills, and also helped me improve my time management in the lab.

This is very personal and reflects on a challenge experienced by this student and how they used a particular employability skill (organisation and time management) to address this challenge and why they plan to use this approach again.

12.11 Appendix 11: TA guide to marking reflections on employability skills

A guide to marking reflections on employability (transferable) skills CHM2911

Students, staff and professional scientists are used to writing about chemistry in an objective way. However, it is very useful to get students to reflect on their experiences in the laboratory in order to evaluate how they are developing, especially in terms of employability/transferable skills and qualities. This is a very important ability for them to develop so that they articulate their skills effectively when they are applying for jobs and can give examples of how they have developed and used each skill. It will also help them identify strengths and weaknesses, improve themselves and gain confidence. Thinking reflectively is something they will also need to do once they graduate and move into the workforce, research or further study, to help them keep learning and improving.

This type of writing is very different from the usual writing you have been marking.
Following are some tips that have been given to students and that you can emphasise to them:

How to reflect:

- Use the first person – "I"
- Write about personal development not subject knowledge
- Include thoughts & feelings
- Be honest
- Identify what went well and what didn't
- Think about how this relates to your previous ideas or experiences
- Think about what you have learned
- Identify one or two key points to take forward for the future – what next?

Some simple questions students have been given to help guide their reflections:

1. What happened? What did you do?
2. Which skill(s) did you need, use, develop, work on and/or learn about?*
3. Did you face any difficulties or challenges? If so, how did you approach them?
4. How did you feel?
5. What went well or what didn't go well? What could you have done better?
6. What have you learned?
7. What will you do in the future? Is there something you would do differently next time? Is there something you would do again?

Please note that students do need to address Q2* above, but they don't need to address all of these points in every reflection. These questions are simply a guide to get them thinking and writing reflectively.

Please note students can reflect on any part of the laboratory exercise and related work – preparation, carrying out the experiment, analysing the results and/or writing it up.

Employability/transferable skills and qualities students could reflect on:

Written communication	Critical thinking
Oral communication	Problem solving
Initiative	Numeracy/mathematical (including data analysis)
Independence	Commercial awareness
Creativity	Adaptability/Flexibility
Use of tools, technology and software	Interpersonal skills
Teamwork	Attention to detail
Organisational skills	Resilience
Time management	

Note: Many of these are listed on page 9 of the student CHM2911 lab manual, which is a good starting point to direct students to.

Marking scheme:

0/1 No employability/transferable skill identified. Student wrote only about what happened in the experiment i.e. chemistry / chemical techniques.

0.5/1 The student identified a specific skill they felt they needed during this exercise and a little personal reflection but still a significant focus on the outcomes of the experiment or other unrelated topics

1/1 Personal reflection focusing on one (or more) transferable/employability skill(s) and how the student demonstrated, developed or learned about that skill and/or how they plan to improve this skill in the future

Notes – In the student lab manual for CHM2911, each lab exercise shows some skills badges. The students can reflect on these badged skills, but they don't have to. They can reflect on any employability skill, as long as they provide a little evidence of how they used or learned about that skill in that exercise.

Example 1
This experiment identified the importance of precision (number of drops) in relation to performing well rounded experiments and obtaining reliable results and observations. Transition metals react in an assortment of ways to produce varying colours and precipitates. This experiment could possibly have been better performed in pairs, so that the working stations were less crowded.

0 marks - This is a poor example of personal skills reflection as it focuses on the practicalities of doing the experiment and on the underlying chemistry. It is not personal (does not use 'I') and doesn't directly identify or personally reflect on any specific employability skill the student used or developed.

Example 2
In this experiment I learnt how to balance equations as well as perform several experiments at the same time, which taught me to manage my time well throughout the experiment, helping me develop better time management skills. The experiment would have been better if the experiments took place after the lectures so there would have better understanding of the experiment.

0.5 marks - As the student mentions 'I', there is some attempt to make this personal and they do make a link to one employability skill (time management), but it stills focuses half the writing on other topics.

Example 3
Today's laboratory practical highlighted many new skills and practices for myself. In terms of skills there are many improvements still to be made such as in my written communication skills in the laboratory. I need to be more clear and concise in my recorded observations as sometimes I try to state too much and forget to make obvious my intention in the observation. Also, I had to work in a team and I found this quite challenging. I quite like to get on on my own so accommodating others was difficult and I think I became quite frustrated. This has highlighted something I need work on - improving my teamwork skills in the future. Overall, this was a challenging session for me both personally and technically but I look forward to improving over the semester.

1 mark - This is much better. The student identifies two employability skills needed in this laboratory exercise and reflects on their personal development of each skill, how they felt and how they can improve.

Example 4
Because I had been really worried about the lab I decided to take some advice from a friend and spend quite a bit more time preparing. I didn't really think it would work that well because I thought if I don't understand it in the lab how will I understand it before the lab. But it freed up quite a bit of time because I had already looked up some words that I couldn't remember from last semester and I had written a draft of my aim which saved me time. I wrote it in pencil so once I knew which bits were correct I just filled it out in pen and didn't have to think about it anymore. I think I'll try to do this in the future because I'll have more confidence I can get through everything in the time I have. Planning and preparing for this experiment in this way showed me the importance of having good organisation skills, and also helped me improve my time management in the lab.

1 mark - This is very personal and reflects on personal successes and challenges and an employability skill (organisation and time management) rather than on the chemistry.