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Reskilling the manufacturing workforce and developing capabilities for the future

Final report 2016

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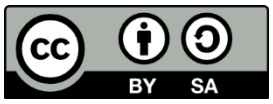

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List of acronyms used

AQF	Australian Qualifications Framework
FU	Flinders University
MOU	Memorandum of Understanding
MSA	Manufacturing Skill Australia
OLT	Office for Learning and Teaching
RTO	Registered Training Organisation
STEM	Science, Technology, Engineering and Mathematics
UTAS	University of Tasmania
VET	Vocational Education and Training

Executive summary

With the maritime and advanced manufacturing industry growing within Tasmania and all across Australia, there will be a growing need for the workforce to have deeper and more complex skill sets in the next three to five years. This project identified the mismatch between the current and future skills from literature and interviews with industry stakeholders. In addition, it reflects on existing pathways to ensure that the skills gap is reduced and future skills needs are being met. The approach the project team took was to interview businesses across the manufacturing, advanced manufacturing and maritime industries in Tasmania. Seven businesses were selected to interview and were either members of the Tasmanian Maritime Network or considered growth industries and industries of importance for Tasmania.

Summary of outcomes and impacts

- A major learning outcome from this project is that there are common needs amongst the manufacturing, advanced manufacturing and maritime industries for future skills despite the diversity in industries.
- The fundamental skills identified by industry for continued growth and effective staff management include basic attributes such as literacy and numeracy, problem-solving, work ethic, IT, leadership and management.
- The emphasis for staff to be multi-skilled has been highlighted across industries.
- Technology is ever-changing and technology-based skills for specific industries will drive training needs for the future.
- The lack of higher-level VET training in manufacturing, advanced manufacturing and engineering has left a gap of skilled staff in Tasmania.
- Retirement of the ageing workforce in these industries will create a skills gap if industry does not address training, development and progression of existing staff.
- All businesses offered some form of in-house training for specialty skills, and most businesses support staff through up-skilling and reskilling of staff via external providers. The relationship between RTOs and industry was stressed as vital to meet training needs.

This project was beneficial to the University of Tasmania (UTAS), TasTAFE and Skills Tasmania in strengthening existing relationships and pathways, and improving the industry outcomes. UTAS and TasTAFE have a strong working relationship to deliver pathways for engineering students, in particular the associate degrees are seen as vital in the development of new pathways for the Tasmanian manufacturing, advanced manufacturing and maritime industries.

The results of this study indicate that there is an identified need for up-skilling and reskilling within the education and training sectors to remain current and industry relevant, especially

where higher-level skill needs are emerging related to Science, Technology, Engineering and Mathematics (STEM) industries. Interviews conducted with the manufacturing and maritime industries identified the need to improve the partnership between the trainers and employers and the necessary inclusion of industry-expert teachers in VET-delivered programs to ensure the skills demand for the future is met. Additional research is needed to understand how best education and training providers can work effectively with industry to address the skills needs of niche businesses in thin education and training markets.

Table of contents

Tables and figures

Tables

Figures

Introduction

Innovative economies require a workforce with a high level of technical skills and scientific awareness, yet worldwide there is a decline in the number of students participating in pre-university science, technology, engineering and mathematics (STEM) (Noyes, Wake, & Drake, 2011). Australia's graduation rates in mathematics, engineering and science are low by international comparison (Office of the Chief Scientist, 2012), providing challenges in meeting qualified workforce needs in the STEM sectors. For example, Engineers Australia often quote that there is a shortage of 20,000 engineers in Australia (Engineers Australia, 2012), and the Australian National Engineering Taskforce (ANET) is attempting to address this shortage by developing practical solutions to what has become an enduring problem with "a renewed focus on building an innovation economy and increasing educational attainment" (Australian National Engineering Taskforce, 2012, p. 58).

Australia's future in the next three to five years depends on a stronger workforce with more qualified engineers and associated professionals with the high-level skills capable of delivering to the needs of growing industries such as advanced manufacturing and the maritime sector. In recent years, Australia's "traditional" manufacturing industries like construction, automotive and forestry have seen a decline in business leaving much of the current workforce looking to utilise their technical skills and knowledge elsewhere.

The nature of manufacturing has changed and, as it now encompasses design, industrial technology and service engineering for example, there is a wealth of "industrial talent" which can be refocussed and leveraged for these workforces' needs. Pathways are a logical response to capturing this talent and paving the way for skills upgrade. Within this refocus of advanced manufacturing, maritime manufacturing and the emphasis on aquaculture, and gas emerge as critical next waves. These pathways afford the necessary access to develop the skills and workforce needs to grasp this next wave (Deloitte Australia, 2014).

The Tasmanian Department of Economic Development, Manufacturing and Services in collaboration with the Tasmanian Maritime Network (TMN) have identified in a recent interim report (Tasmanian Maritime Network, 2013) that the Tasmanian maritime industry will require 50 new positions in the next 18 months (an increase of 11 per cent) that have high-level skills (such as naval architects, design engineers and draftspersons) for the future development of this industry. The key findings from this report (Tasmanian Maritime Network, 2013) are based on interviews with 15 firms, all from the southern region of Tasmania (excluding educational institutions, government and Incat). The current workforce profile consists of 85 per cent full-time employees with the other 15 per cent made up of labour hire, casuals, apprentices, part-time and interstate workers.

Manufacturing is a major industry within the Australian economy. There has been a great deal of interest in the up-skilling of the current workforce across this sector (Smith, Courvisanos, Tuck, & McEachern, 2012; Allison, Broun, & Lacey, 2013; Manufacturing Skills Australia, 2014; Transportation and Logistics Industry Skills Council, 2014). More specifically, industries want to build a learning culture within their workforce (Smith et al., 2012), up-skill qualifications from the technical level through to management (Allison et al., 2013) and provide long-term career paths for employees (Transportation and Logistics Industry Skills Council, 2014). Therefore, it is essential to not lose this skills base and *can do* attitude in the

current manufacturing workforce, and growing industries should be focused on the opportunity to reconfigure and retrain wherever this is needed. Having a strong relationship with an educational provider is seen as integral in the ability to provide these solutions.

The advanced manufacturing industry in Tasmania is small but vital within the economy. It represents 10 per cent of the state's economic activity and employs 10 per cent of the state's workers (Tasmanian Government, 2014). In some regions, manufacturing plays a larger role in the economy, for example in the northwest of the state, manufacturing employs more than 30 per cent of the region's workforce (Allison et al., 2013). With economic downturns and changes to the Tasmanian economy occurring (such as forestry), the workforce is set to change in the next three to five years. Businesses within the Tasmanian manufacturing industry have been previously surveyed (Enterprise Connect Innovative Regions Centre, 2013; Allison et al., 2013) to identify what were the current and future needs of this industry.

In today's business environment, industries have to utilise their existing workforce to the fullest extent possible, leveraging the knowledge base within the organisation through learning and skills enhancement programs implemented across the board. Hence, educating staff to ensure adaptability and effectiveness in the industry, which may require reskilling or up-skilling, will become essential in this competitive marketplace.

Project Objectives

The objectives of this project will be to:

- Identify the existing skills from down-turning manufacturing industries.
- Identify the skills required by the Tasmanian Maritime Network as skills for future growth.
- Identify the mismatch between the existing skills set in the current manufacturing industry and the future required skills within the Tasmanian maritime and advanced manufacturing industries.
- Identify pathways which exist or what is needed to be developed to meet these future needs.

Literature Review

Background

In Australia, manufacturing plays a major part in the economy at both a national and local scale and extends through multiple industries (Manufacturing Skills Australia, 2014; Australian Government, 2013). Manufacturing produces approximately $100 billion in output annually (Manufacturing Skills Australia, 2015), represents approximately eight per cent of jobs and is the fourth largest employment sector in the nation (Australian Government, 2013). The flow-on effect in manufacturing jobs is large with every job creating another two and a half jobs in other sectors (Giffi, McNelly, Dollar, Carrick, Drew, & Gangula, 2015). These jobs are as diverse as the industry and span all education, qualification and skill levels. Low qualification rates are widespread across the industry with

45.2 per cent of the workforce without any post-secondary qualifications (Australian Government, 2013).

The industry has experienced significant change in the past five years from the onset of the Global Financial Crisis to the rapid developments in technology and the slowdown of the mining boom within Australia (Manufacturing Skills Australia, 2014, 2015; Australian Government, 2013) resulting in an industry decline over a number of years (Tasmanian Department of State Growth, 2014). This change has had far-reaching effects across the manufacturing sector and related industries on the job availability, skills required and current training and education. As a result of the downturn in traditional manufacturing, advanced manufacturing and its related industries have been identified as a growth industry not only in Tasmania (Beddie, Creaser, Hargreaves, & Ong, 2014) but also nationwide (Committee for Economic Development of Australia, 2015). In addition, there has been a shift from the manufacturing of goods to a service-based industry as part of a larger supply chain (Manufacturing Skills Australia, 2015).

The skills base needed in the 21st century is one that encompasses a mastery of core knowledge in a key field with a number of well-developed workplace skills such as critical thinking, effective communication and willingness to engage in continued learning (Business-Higher Education Forum, 2013). Multiple changes in career are likely and now expected in the workforce; having strong base knowledge to understand emerging digital technologies and new approaches to problem solving will be required (Deloitte Australia, 2014).

The scope of this review is to identify the current key skills in the manufacturing, advanced manufacturing and maritime workforce; skills gaps, future skill requirements; current educational pathways, and potential areas of growth in Tasmania. At the time of this review, the manufacturing industry in Tasmania is undergoing significant change especially in the north west of the state with recent layoffs at Caterpillar Underground Mining in 2015.

Skills in the manufacturing and maritime industries

There have been numerous reports and papers over the last five years looking at the manufacturing and related industries, their skills, training needs and contribution to the Australian economy now and into the future. These reports have been synthesised into this review.

Issues and needs of the current industry

The manufacturing industry is continually changing and with that there are concerns for the future. Against this backdrop, skills predictions for growing industries can be quite challenging (Beddie et al., 2014; Committee for Economic Development of Australia, 2015).

The major industry skill concerns are focused on the inadequate fundamental numeracy and literacy skills of the workforce (Australian Government, 2013a; Business-Higher Education Forum, 2013), problem solving, critical thinking, and effective communication skills and engagement in learning (Business-Higher Education Forum, 2013). Other concerns are the ageing workforce (Australian Government, 2013a; Beddie et al., 2014), skill shortages, the level and importance of science, technology, engineering and mathematics (STEM) skills in current training options (Australian Government, 2013a; Toner & Stilwell, 2014) and the

ability of the workforce to adapt to the changing industry (Australian Government, 2014). The manufacturing and advanced manufacturing industries will be strengthened through improving skills which generate innovation (Parilla, Trujillo, & Berube, 2015). The workforce needs attributes such as team spirit, willingness to learn, commitment to the organisation, capacity to foster innovation and improve business performance (Mendes & Machado, 2015). Prinsley & Baranyai (2015) discovered that employers found their STEM-trained employees to be the most innovative and adaptable to change. They also found that the top four skills that were rated by employers as the most important were active learning, critical thinking, complex problem solving and creative problem solving.

A major issue concerning the manufacturing industry is the advanced age of employees. In 2014, 41 per cent of the workforce was over 45 years of age (Beddie et al., 2014), increasing to 43 per cent in 2015 which is higher than the average age for all other industries of 39 per cent (Australian Government, 2013a, 2015). The uptake of training and apprenticeships is not meeting the potential knowledge gap that will exist as the workforce approaches retirement. A focus on training and education will need to occur in order to avoid significant skills gaps which will become more pronounced as the technology and innovation in the manufacturing industry evolves (Manufacturing Skills Australia, 2015). Manufacturing Skills Australia (MSA) (2015) predicts capacity will decline in the manufacturing industry as a result of the skills gap due to the ageing workforce.

Emerging skills in advanced manufacturing include supply chain management, technological skills, operational management skills, technology and systems expertise. Nearly half (49 per cent) of the employers who participated in the study (n=114) identified skilled workers as the primary issue affecting their business (Transportation and Logistics Industry Skills Council, 2014). Therefore effective and targeted training for the workforce is needed in the industry (Transportation and Logistics Industry Skills Council, 2014).

Numerous reports on manufacturing in Tasmania identify the largest constraints in growing businesses and industry as being skills gaps, shortages and the small size of the skill base in Tasmania (Enterprise Connect Innovative Regions Centre, 2013; Allison et al., 2013). Developing skills and training for Tasmanian North West manufacturing industry in particular are key issues. A shortage of suitably qualified trade and professional staff is currently impacting growth of firms and has been identified as a critical issue for the future development of businesses located in that region of Tasmania (Enterprise Connect Innovative Regions Centre, 2013). The list of skills needed is extensive and is covered in Table 1 of this report. Enterprise Connect's research highlighted the need for a whole-of-industry approach to skills development. Common issues are the basic mathematics knowledge of young people, mechanical knowledge or "nouse", problem-solving skills, attitudes and willingness to work. The findings of this Tasmanian study reflect the issues seen in manufacturing industry nationally and internationally (Manufacturing Skills 2014, 2015).

The skill needs of the Australian maritime and ports sector are similar. In 2014–2015 the sector had a revenue of $16.9 billion with added value of $9.2 billion. It is expected to have a sector job growth of 4.7 per cent from 2013 to 2018. Its workforce is one of the oldest in the country and is ageing 1.7 times faster than all industries (Transportation and Logistics Industry Skills Council, 2014). Due to limited ship-based training berths being available for

incomers, there is a gap between the skills supply turned out by established training institutions and industry demands. There is also strong international competition for skilled port workers, with regional and remote ports facing the most difficulties in recruitment. The Transportation and Logistics Industry Skills Council has identified a skills gap in automated systems of work, electro-technical, dredging and offshore-specific requirements such as occupations of marine engineer and deck hand/integrated rating (Transportation and Logistics Industry Skills Council, 2014). This is consistent with the skills gap identified (Table 1) by the Tasmanian Maritime Network (2013).

In addition, employers interviewed for the report identified the need for increased ability in problem solving, leadership and management, teaching and training, language literacy and numeracy, information technology and financial management (Transportation and Logistics Industry Skills Council, 2014). Employers also reported that 53 per cent of the education and training was sought via traineeships, apprenticeships or graduate programs, with 73 per cent developed by the company themselves through the provision of up-skilling, mentoring, training and career progression (Transportation and Logistics Industry Skills Council, 2014).

Numerous reports focus on the importance of STEM to the growth and competitiveness of Australia on the world stage (Office of the Chief Scientist, 2012, 2014; Australian Government, 2013a; Manufacturing Skills Australia, 2015; Committee for Economic Development of Australia, 2015). STEM skills are the fundamental skills of the manufacturing/advanced manufacturing and maritime industries (Manufacturing Skills Australia, 2015) and having strong STEM understanding will create a workforce which will be able to address the changing needs of industries. The need for STEM in industry is not being met and it is of concern that the current education and training will meet this growing need for the workforce (Manufacturing Skills Australia, 2015).

Shortages are occurring in the areas of oil and gas production workers, maintenance engineers and trade workers, fitter mechanics, pipe welders and coded welders and licensed aircraft mechanical engineers. These skills shortages are exacerbated when industries are located in regional areas (Manufacturing Skills Australia, 2015).

Education and training sector

Australian post-secondary education is divided between the vocational education and training (VET) and higher education sectors. The two sectors differ in many ways, particularly in learning approach and students' characteristics (Karmel, 2008), where VET learning is competency based, the higher education sector is knowledge based (Karmel, 2008). The sectors' learning and teaching approaches and cultures are linked to the desired employment outcomes for each sector's graduates. Training needs for the manufacturing industry span both the VET and higher education sectors. In many cases, future skills required by the industry needs fall into a gap between the two (see Table 1).

In addition, capable students in regions have limited access to higher education, often choosing trades (VET) pathways (Australian Workforce Productivity Agency, 2012) where articulation pathways to further their skills are often "piecemeal" and not helped by cross-institutional barriers. Other issues contributing to cross-institutional barriers are the significant advances being made in the areas of robotics and automation in industries such as mining and manufacturing. These advances are leading to a change in the nature and

focus of the knowledge and skills required to support industry. Thus, there is a need for a more flexible engineering curriculum as well as an alternative skills pathway for those students entering these fields of study. Those currently in the workplace wanting to up-skill are met with the reluctance of industry to release workers for study for any significant periods due to the associated loss of production. These concerns, ever present in regional Australia, require innovative solutions. One such solution is to provide a vehicle that improves access, industry relevance and retention while generating economic and social benefits through a better skilled and stable workforce for regional areas.

VET

The VET sector has traditionally supplied competency-based training for industries, with direct links between qualifications and jobs (Wheelahan, Buchanan, & Yu, 2015). It has worked with individual industries to develop qualifications where a skills gap is apparent (I. Patterson, personal communication, 8 October 2015). However, the VET sector will need to continue to work with industry to address the changing skills needed and manage the workforce development priorities to meet the needs of niche and thin markets. Niche markets are seen as the future of manufacturing, and are directly related to thin markets for specialist skills. Thin markets also characterise regional Australian manufacturing (Ferrier, Dumbrell, & Burke, 2008). An ability to develop customised training solutions for individual businesses is a consequence of thin markets that has been highlighted by Manufacturing Skills Australia (2014). Internal, work-based traineeships have been suggested as a technique for dealing with the effects of skill shortages (Giffi et al., 2015). The challenge for the VET sector will be to train students for a qualification, but also to make that qualification transferrable, with strong foundations in STEM, and high-level skills such as critical thinking and problem solving (Manufacturing Skills Australia, 2014).

While the VET system provides a national framework, there is already considerable room to customise the approach and process at the implementation stage. This flexibility to meet the needs of employers while maintaining national consistency is a critical feature in ensuring the system remains relevant in the future. To remain relevant for the future Australian workforce, qualification design will need to enable both global relevance and local flexibility, and support the development of adaptable and broadly applicable workforce skills as well as niche industry specialisation. In addition, skill sets are considered a useful option to address business needs for a cost-effective, time-efficient, bite-sized solution for equipping workers with valuable skills. Skill sets can act as significant pathways to further learning and qualifications in a complementary system to meet the industry's requirement for adaptive and flexible responses, while retaining the opportunity for broader national recognition (Transportation and Logistics Industry Skills Council, 2014).

The transport and logistics workforce is increasingly required to operate complex technology in a highly technical environment. A study from 2013-2017 found that the demand for qualifications at the Certificate IV level and below is declining in many areas, squeezed by both the demand for higher-level qualifications and the growing use of skill sets (Transportation and Logistics Industry Skills Council, 2014). Current VET enrolments are disproportionately high in Certificate I/II and Certificate III/IV qualifications. In order to respond to the pressing workforce needs of the industry, it is critical to encourage student enrolments in diploma and advanced diploma-level qualifications in the coming years (Transportation and Logistics Industry Skills Council, 2014).

Similar findings were provided in the report for the maritime and ports industry. The maritime industry faces challenges with a mismatch in the supply of skills that established training institutions offer and industry demand. In addition, higher-level skills related to new technology, business skills, project management and engineering are required. With a rapid growth in the cruise ship market, sustaining demand for seafarers requires multi-disciplinary skills at all levels, hence requiring the improvement of partnerships between industry and VET providers to ensure industry-values learning outcomes (Transportation and Logistics Industry Skills Council, 2014).

Industry–education and training sector partnerships

Partnerships between industry and education providers are key to keeping the training current and relevant to changing industries (Committee for Economic Development of Australia, 2015). Industry partnerships should extend beyond VET. Industry should engage with schools and community colleges as well as VET (Giffi et al., 2015). Work-integrated learning programs benefit employers, students and help to bridge the education–industry divide (Committee for Economic Development of Australia, 2015). The Australian Government (2014) has identified that if the manufacturing industry is to grow it will need tertiary graduates and that requires industry and universities to develop a stronger collaboration.

VET qualifications and higher education degrees should be co-designed in partnership with industry (Burnett & Thrift, 2015). Wheelahan et al. (2015) also support closer links between education and industry. They found that "vocational streams" which serve as an intermediary between the job-specific competency-based qualifications and the generalist higher education may be useful in assisting the workforce adapt to the changing skills of the future. Evidence to date suggests such a pathway is difficult to achieve, with regional students often limited by their choices and access to higher education and VET programs. Regional higher education and VET campuses also struggle with the viability of engineering courses in geographically scattered and thin markets. While there are some excellent distance education programs, these are often not appropriate for many prospective students who need personal support to make the transition into education and training at a tertiary level (Battersby, 2013).

There is an overall need in the manufacturing industry for workplace flexibility for up skilling and reskilling (Smith et al., 2012; Australian Government, 2013b; Manufacturing Skills Australia, 2015). A major review of the resource sector from 2009 to 2011 led to changes focusing on skills needed by the sector, training and up-skilling of the current workforce (Australian Government, 2013b). Promoting partnerships between industry and tertiary education providers were a focus to promote planning, more apprenticeships and fast-track adult apprenticeships. The resource sector has also worked to develop partnerships with schools and tertiary education providers to increase student participation and educational attainment and ensure increased engagement with mathematics and science to improve employment and education pathways (Australian Government, 2013b). In 2015, nearly half the employers (46 per cent) surveyed by MSA indicated that they prefer training to be onsite and supervised by the employer. Employers (and employees) want training to be fully flexible, onsite, for small numbers of students, consistent and high quality on demand. This is another manifestation of the thin market issue, making the VET provision needed by

industry unviable for many RTOs especially in regional areas and particularly for specialist qualifications (Manufacturing Skills Australia, 2015).

Future skill requirements

Future skill requirements for the manufacturing, advanced manufacturing, maritime and related industries identified in the literature cited above are listed in Table 1.

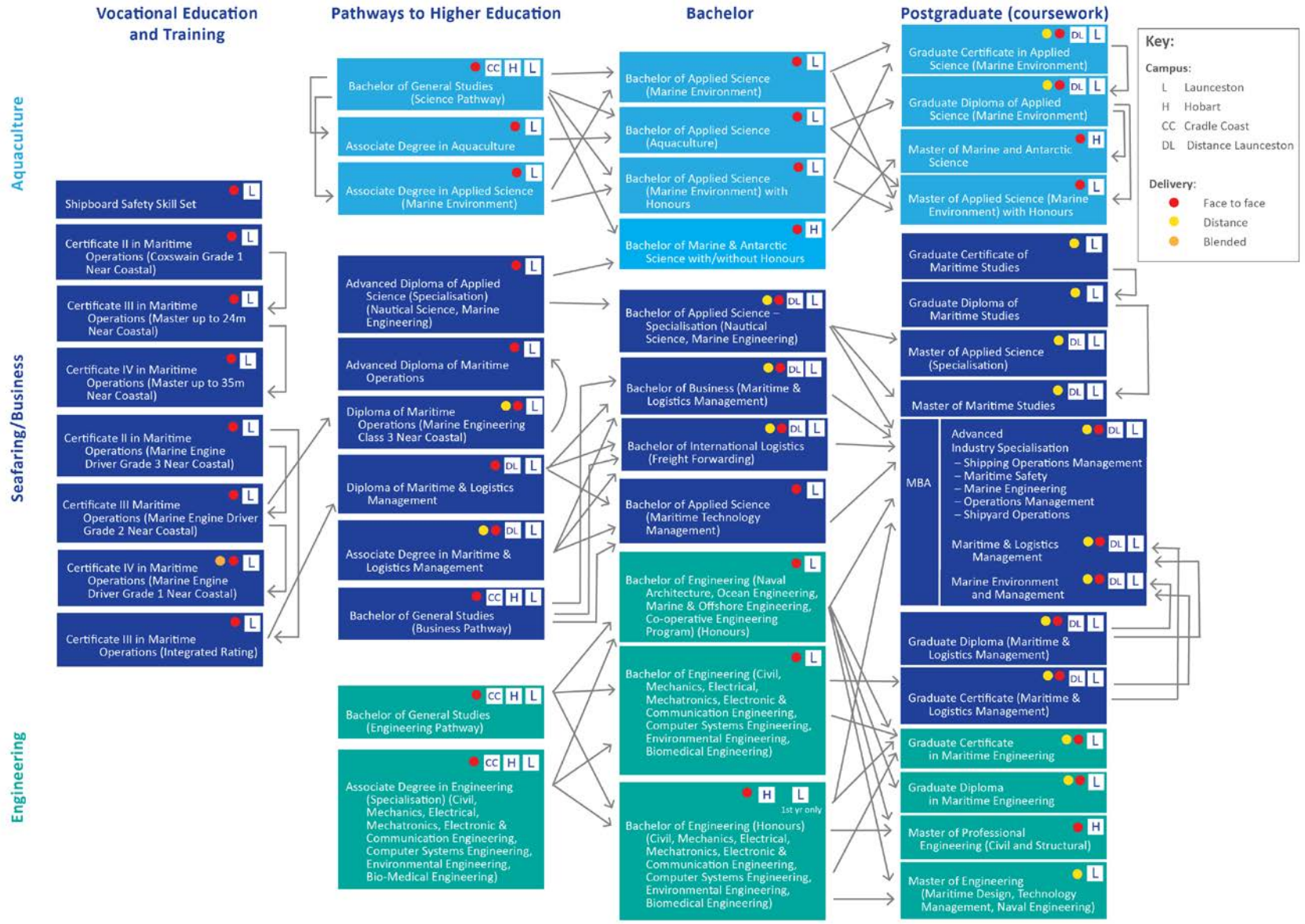
Table 1. Future skill requirements for the manufacturing, advanced manufacturing and related industries gathered from published reports and papers.

Future Skills	**Industry**	**Reference**
Design/CAD, Drafting, lean manufacturing, customer service, CNC systems, automation/robotics, PLC programming, fitters, mechanics, mechanical, boiler makers, welders, sheet metal, metal fabrication, electrical and diesel technicians, marketing, business, administration and finance, accountancy, production management, quality assurance, leadership, supply chain management, surveying, engineering and geology	Engineering and engineering services in north west Tasmania	Enterprise Connect Innovative Regions Centre, (2013)
Balance of technical and theoretical skills, high-level application of STEM and literacy skills	Advanced manufacturing and mining equipment, technology and services	Beddie et al., (2014)
Personal values, skills in: interpersonal communication, problem solving, technology, leadership and entrepreneurial and informational skills	Manufacturing	Rasul, Rauf, & Nor, (2014)
Leadership, business and workforce planning skills, developing technologies, developing global markets, lean and agile production management, customer service, management, STEM, problem solving, intellectual property management, waste management, global supply chain management	Manufacturing	Manufacturing Skills Australia, (2014)
Supply chain management, business management, systems and technological skills, fleet management, safety management	Transport and logistics	Transportation and Logistics Industry Skills Council, (2014)
Problem solving, leadership and management, teaching and training, language literacy and numeracy, information technology and financial management, automated systems of work, electro-technical, dredging, and offshore-specific requirements such as occupations of marine engineer and deck hand/integrated rating	Maritime	Transportation and Logistics Industry Skills Council, (2014)
Naval architects, design engineers, draftspersons	Maritime	Tasmanian Maritime Network, (2013)
Management skills, problem solving, STEM,	Manufacturing	Manufacturing

innovation/design skills, multi-skilled, broad-based capabilities, IT/digital skills, higher-level interpersonal/organisational skills, creative thinking, and the ability to adapt		Skills Australia, (2015)
Active learning, critical thinking, complex problem solving, creative problem solving, interpersonal skills	Construction, electricity, gas, water and waste services, manufacturing, mining, scientific and technical services	Prinsley & Baranyai, (2015)

Pathways available at the University of Tasmania are available to transition students from a VET qualification (Certificates II–IV) to a diploma into post-graduate studies (Figure 1). These pathways currently exist in maritime/marine, manufacturing, advanced manufacturing, engineering and related industries.

Figure 1. Pathways available at the University of Tasmania for industries within the manufacturing, advanced manufacturing and maritime industries.



Conclusion of literature review

While Australia's manufacturing, advanced manufacturing and maritime industries' supply chains generate significant benefit to the Australian economy, productivity is adversely affected by a shortage of suitably skilled labour. There is an ever growing need to increase productivity, innovation and international competitiveness. Australia needs a more flexible, adaptable and adequately skilled workforce.

The manufacturing workforce covers a wide range of skill levels from lower VET certificates to higher education degrees. Although the demand for workers at the lower end of the qualification spectrum is falling, an ageing workforce means new workers must be trained to replace those who retire. Training in foundation skills of literacy and numeracy and general "employability" skills and attributes are required. At higher skill levels, the workforce needs applied technical skills and research-informed knowledge, as well as so-called soft skills such as problem solving, critical thinking, creativity, management and communication. The rapidly changing nature of the industry means that education and training must occur through workers' careers.

The niche nature of many of these geographically scattered businesses and associated thin education and training markets make it difficult to provide viable professional and para-professional engineering and related programs. Addressing skill shortages in manufacturing requires a strong partnership between educational providers and industry, including workplace training. Partnerships between schools, higher education, VET providers and industry would address critical issues constraining industry productivity and inhibiting the educational and career opportunities.

Project Approach

This project received ethics approval from the Tasmania Social Sciences Human Research Ethics Committee (H0015075).

Qualitative data on current and future skills were collected through semi-structured interviews with individual businesses in the manufacturing and advanced manufacturing industries in Tasmania. The businesses selected to interview were either members of the Tasmanian Maritime Network or considered growth industries and industries of importance for Tasmania. A range of businesses was selected to ensure a mix of size, age of company and diversity within the industry. Purposeful sampling is an important part of the qualitative research design because it allows the research team to understand specific issues which are central to the research topic (Patton, 2015).

The project manager emailed an invitation to participate in the research, and 24 businesses were invited to participate. Of these 24, seven businesses accepted the invitation, two declined and 15 did not reply. The businesses nominated an appropriate participant which was generally a human resources manager, training manager or similar. All interviewees had a good knowledge of the company's skills and developing needs for the future.

A semi-structured interview schedule was developed by the research team and was comprised of open-ended questions in three categories: industry questions, current skills and future skills and developing needs (Appendix C). Interviews were conducted by

members of the research team. Interviews were audio recorded with the participant's permission and transcribed verbatim for analysis.

Transcripts were coded thematically (Creswell, 2014) and themes were generated from the data which is consistent with an inductive analytic approach (Ryan & Bernard, 2000). The themes were then combined into a smaller number of overarching categories that became the framework for the major findings.

Project Outputs and Findings

This section describes the themes which emerged from the semi-structured interviews with the individual businesses. The participating businesses (n=7) ranged from small (<50 individuals) to large businesses with over 4,000 employees. There were three age categories for the participating businesses: three businesses were established more than 80 years ago, another three were established between 30–80 years ago and one company was less than 20 years old.

Table 2. The range of industries interview.

Industry	**# of businesses interviewed**
Renewable energy/engineering	3
Maritime/marine	3
Advanced manufacturing	1

Employees

Qualifications of current staff

Current staff had a wide range of qualifications that depended on the nature of the company. Staff ranged from having no formal qualifications to PhDs in higher-level positions. There was a general trend that entry-level staff had a trade or VET qualification but this was not always the case.

> "…if they don't have a qualification doesn't mean they don't get employed…we will hire people straight out of school, and we will actually put them through their associate diplomas and their advanced diplomas and those sort of things, to get them skilled." [company G]

In one company, most of the production staff "would be mainly unskilled and skilled on site…Most of the people are actually multi-skilled…they get rotated round" [company C]. Regardless of the staff qualifications, all businesses retrained their staff for their specific industry needs. The importance of having staff who were multi-skilled was strongly emphasised throughout the interviews, especially for management to have that deep understanding of the skills that staff possessed. Most of the multi-skilling was conducted as on-the-job training as opposed to formal qualifications.

Work ethic

The work ethic of younger employees was a theme in more than half of the interviews. With businesses noting the importance of work ethic and maturity of staff and the lack of work ethic in the younger generations:

> "Work ethics is something that's very important, it's something that we do see, I don't know, the current generation sort of look at it that they're doing you a favour by coming to work each day." [company I]

Businesses are investing in the younger generation for succession planning due to the ageing workforce as many have a workforce comprised of long-term employees where often the average age of the staff is over 45. This is common in the manufacturing and advanced manufacturing industries and was highlighted in the current literature (Manufacturing Skills Australia, 2014; Committee for Economic Development of Australia, 2015). This is not only the case for an unskilled workforce but also in university graduates where one company highlighted that they prefer to hire graduates after they have gained some experience elsewhere for many of the same reasons.

> "…also a level of maturity as well, so we often pick graduates not the first year out, they might be a couple of years out or whatever. So I think the ones who tend to stand out are the ones with just a little bit more life experience and maybe they've gone and done something else first. Which means they come across in an interview a bit more confident and assured, because they've had a crack at something real." [company H]

Future staff needs

Staff needs for the future are changing in the range of businesses interviewed. For some, technology is changing their staffing needs and for others, the demand for their product will directly translate into more jobs.

Technology is driving the needs for the future and businesses which are involved in production are indicating that with changes in technology, they will have staff reductions generally at the lower level. Businesses will be looking for a more skilled workforce and, as indicated by company F, "the role will change from one of hands-on to technology-based, focused, skilled, in every way…leadership, IT skills are what we need for the future". When company F was asked what their staff needs would be in 3–5 years, they replied, "Less at the lower level". Technology will increase the productivity and efficiency and company C expects it will "improve efficiencies and speed up the [production] process, cut down the number of workforce, you know, people cost money to employ, unfortunately".

Other businesses were experiencing a period of growth and indicated that they would be hiring staff (in relatively large numbers) currently and in the near (1–2 years) to medium future (3–5 years). These businesses have implied they will be increasing their staff by 15

per cent in some cases and more in others. Some of these employees will be temporary in order to meet immediate staffing demands but all staff will be retrained for the specific industries. For a few businesses, the staff demands will be met through multi-skilling their current employees.

> "Well, one thing that we've tried to do over the years is to multi-skill our workforce and why we've done that is because we go through these peaks and troughs, to try and maintain all the different trade groups in the numbers we need is where we become very inefficient. So we have spent a lot of time and effort trying to multi-skill our trade group. So, you might be working as a fabricator this week, but as our workload changes…." [company I]

> "…so as we need them we just sort of, you know, if you're looking and you're keen, then we…just retrain internally." [company G]

Skills

Reskilling and up-skilling staff

All the businesses that were interviewed, with the exception of one, had established training programs for reskilling and up-skilling their staff. These varied from fully funded programs including time off for attending training to retrospective payments on completion with the employee responsible for the time needed to attend.

> "We're offering it to you, we're going to pay for it, the rest is up to you." [company F]

There was variation to these programs and often it depended upon the level of the employee. Generally, lower-level employees who required specific training for their position were catered to. The one company [company C] which did not have an established training program had a culture where if they needed a specific skill or qualification they would "go and employ someone that's already done that on their own behalf". The attitude in this company at the time of interview was beginning to shift, with management pushing for support of a few employees to be retrained.

> "We're trying to push for the betterment of the worker, you know, these people and we think they've got potential." [company C]

Amongst the businesses there was a general culture about up-skilling and re-skilling that was very positive. The businesses in this study all require a high level of technical skill and will reskill employees to meet their needs.

> "Regardless of what level they come in we'll always up-skill. So regardless if you came to us with all the qualifications relevant to your role we would still...the application into our industry will be slightly different, so we'll up-skill you into power processes, we'll up-skill you onto our best practice because being an industry leader

> we want you to that level, so regardless of what level you'll come in at there will always be an element of up-skilling." [company T]

> "…when you employ someone, and you train them to 80 per cent before you send them out on the floor, they'll get to the 100 per cent. You know, with the interaction with others. But you send someone out before they get to that, they'll only ever get to 80 per cent, because you haven't shown them the fundamentals, you know?" [company I]

Many of the businesses emphasised the benefit of multi-skilling their staff, and this provided the opportunity for employees to move within the company and "come up through the system" [company C] in the larger businesses. Another company said that "multi-skilling is going to help people going forward" [company I].

Core/fundamental skills

An issue that was alluded to in the interviews from two or three of the businesses was the literacy and numeracy skills of staff. These businesses had a large number of staff currently in non-skilled labour jobs.

> "…we do generally have a literacy problem…, and I see that in the manner that our boys complete basic forms, where some of them can't adequately construct a sentence. So if you throw them into a certificate course, how much are they going to get out of it? [company F]

As mentioned in this quote, it becomes a major issue for training, reskilling and multi-skilling of staff members. Company F spoke in more detail about training assessments for staff with literacy issues and the need not to alienate them but develop the internal training to be "as coherent as possible…, deliver it verbally, and any assessments to be done on the day with the assessor or the facilitator, otherwise it won't work".

Skills gaps and future needs

A major need identified by the interviews was in leadership. Half the businesses were investing their staff into leadership training as this was an identified need by the company for continued growth and effective staff management.

> "…this is an area that we all need to hone in, leadership…we are focusing heavily on a leadership program." [company F]

> "…frontline leadership training…how to be an effective leader, and the skills we look for with those that are leading teams or influencing the business." [company T]

These businesses were either contracting businesses from mainland Australia to train in-house to provide specialised leadership training customised for their specific industry or sending employees out of the state for the training. Other gaps in skills identified were

focused on changing technology, and mentoring for staff. Changing technology will be discussed below.

With the focus on technology and its strong influence on the future, the point has been made about retaining those basic core skills to engineering and ensuring that they are not lost in the trades. Also important was the need to teach trades in a way so that there is a real understanding of the skills and knowledge needed for flexible, critical thinking and decision making.

> "I think they'll need to have a lot of the traditional skills, and they'll still be very much valued. A good understanding of it, of how it works, why it works, all those sorts of things and it's the same with the trade skills. I think that's probably where we've, you know, missed the boat. We don't teach the tradesmen the basic skills, we probably teach them a whole lot about, you know, business and economics and marketing and, you know, how to balance their budgets and things like that, but if they don't have the basic skills it's very hard for them to apply those things. So I think the challenge is we've got to keep giving people the basic skills, engineers still be able to…need to be able to, you know, understand and calculate why things and make things work. But it's the broadening of those skills and the adding on of those skills so that they can take those…take that core base, understand how things work, but then…be much more capable of reacting and understanding the business world, the market, what's driving change and be a lot more flexible." [company H]

Training

VET providers meeting the needs of industry

The businesses interviewed utilise both the TAFE and private registered training organisations (RTOs) for training their staff. There was an overwhelming level of dissatisfaction with the training options available, however, with these specialised manufacturing and advanced manufacturing industries much of the training required is highly specialised. Nonetheless, it is clear that there are issues between industry needs and the training providers (both the TAFE and private RTOs). In Tasmania, the VET sector is aware of these issues and has engaged with industry to improve the relationship between student outcomes and industry needs. In 2013, the advanced diploma qualification was cancelled in Tasmania but the need for it still exists in the manufacturing and engineering industries.

> "…18 months ago [TAFE] taught out that final year of advanced diploma subjects…it creates a massive gap, like, were looking to put a cadet on, but there's no pool to pick from…there's nobody with those skills that we actually require, because being paid employment, you need to put them on the floor and they need to become useful as quick as possible, so there is currently no engineering course that gives them that skillset." [company G]

> "TAFE system and stuff is disgraceful, to be honest. Disgraceful. Like last year there was no diploma in the mechanical trades available. This year's supposed to have started in about June. I was hoping the uni might pick it up but...yeah, they didn't. And yeah, the TAFE are going to be picking it up again around June, they reckon, I've got three at the moment ready to go into that." [company C]

Most interviewees indicated that the skills of the students graduating with a VET qualification were lower than expected. "We are finding skills, hand skills, trade skills, basic practical skills lacking in a lot of apprentices coming to us from well, TasTAFE and things like that" [company H]. Another company stated that in "a whole range of areas we just didn't feel that the modules had kept step with our industry" [company T] and that there was a "…down skilling of the trades...They've got a really good solid base in theory and all the rest but their practical skills are very, very minimal" [company C].

One interviewee was previously a teacher at a VET training organisation and "the lack of ability of the people coming out of the Polytech is why I got into teaching at the Polytech." "I can teach them what they're doing, but they need a core skill which is why we're reliant on the VET courses. The problem is the VET courses are not necessarily up to speed" [company G]. The same interviewee also said that "the course deliverers were not maintaining their skill base, and some of them have the right knowledge and the right understanding of things, but they aren't able to deliver it in a way that helps people actually educate themselves, or they rely on people educating themselves other than delivering it well" [company G].

All of the businesses had developed some level of in-house training to cover their needs. Some businesses use the VET system for some levels of training and provide the rest through in-house training as demonstrated by the following examples:

> "TasTAFE mainly for the technical skills and then internal training for the industry specific skills." [company H]

> "So we're an industry leader on our safety systems, and we expect the staff that attend the training with a third party to receive the same level of health and safety training as we present. We're finding that that's falling behind…There is also the core modules within the Cert III…not in line with current legislation or what we would deem is best practice for our industry." [company T]

> "And it needs to be in-house and it needs to be very interconnected by the managers that have been here for many years and understand what [the company's] all about." [company F]

> "…we do all that in-house now, where once upon a time we went through TAFE." [company I]

> "…we've sort of been covering a few of the gaps so we've been organising our own training, like, internal training and things like that to keep up." [company T]

> "…we just believe that we have more skill in-house to teach." [company W]

One interviewee highlighted that direct communication with the VET providers and building a strong relationship with them was the way to overcome their training needs:

> "We have developed a close relationship over the last two years given that, for the last 10 or 15 years, the education that was provided wasn't very specific to what we needed. So we sat with them and pretty much told them that, 'It needs to be more specific, your teachers need to deliver the content in a manner that is attractive and coherent to our [staff], who, the last thing they want is to sit in a classroom setting and write notes'". [company F]

Information Technology

An area of constant change and increasing importance for the manufacturing, advanced manufacturing and engineering industries is technology. All businesses interviewed mentioned technology in some way, but IT skills, data collection and changing technology as important areas for skills development was highlighted in nearly all the interviews. This is demonstrated by the examples below:

> "…because we're a pioneering industry, the machinery, the equipment that we use is always developing so fast, so we're going to need skilled operators to use that." [company T]

> "…we are identifying at all levels, IT skills are so, so important and are so lacking…this is not an isolated problem, it's company-wide. From top to bottom, we have to be IT-savvy." [company F]

> "…we have a lot of IT infrastructure…so to find people skilled in that area is a problem." [company W]

> "…technologies are changing as well and the market's changing. So lots and lots and lots and lots and lots more data. Yeah, and an interesting decision to make is how much to engage and how little to engage with data…just because it's there, doesn't mean it's valuable…the prospect of having learning systems or smart systems that can interrogate that data and, you know pop up there's a trend change or whatever, you know, that probably I reckon a potential area that we should be looking at." [company H]

To summarise, the key findings are as follows:

- The workforce in these industries is ageing and this will create a skills gap if industry and education and training providers do not act quickly to address training of both new and existing members of staff.
- The crucial requirement for staff to be multi-skilled has been highlighted across industry.
- Technology is ever-changing and technology-based skills for specific industries will drive the needs for the future.
- The fundamental skills identified by industry for continued growth and effective staff management include basic skills such as literacy and numeracy, problem solving, work ethic, IT, leadership and management.
- All businesses interviewed offered some form of in-house training for specialty skills, and most businesses supported staff through up-skilling and reskilling of staff via external providers. The relationship between the VET sector and industry was stressed as vital to meeting training needs.
- There are common needs amongst the manufacturing, advanced manufacturing and maritime industries for future skills despite the diversity in industries.
- The lack of higher-level VET training in manufacturing, advanced manufacturing and engineering has left a gap of skilled staff in Tasmania.

Discussion and Recommendations

The objectives of this project were to identify the skills needed for the future for the manufacturing, advanced manufacturing, maritime/marine and related industries in Tasmania, as well as identify any mismatch between the current skills and future needs. This project has identified a number of future skill needs from interviews with manufacturing businesses. These align closely with skills identified in a review of the literature. The Australian Qualifications Framework (AQF) describes qualifications in terms of the nature and complexity of skills (Australian Qualifications Framework Council, 2013). The manufacturing industry requires skills levels from AQF certificates at the lower end to higher education post-graduate degrees.

Future skill needs identified include: fundamental skills such as literacy and numeracy; written and oral communication skills; interpersonal skills; technical skills involving dexterity and the use of methods, materials, tools and instruments; cognitive and creative skills involving the use of intuitive, logical and critical thinking, and management skills.

The course learning outcomes of the UTAS VET, undergraduate and post-graduate programs (Figure 1) are mapped against the AQF, listing the knowledge and skills appropriate to each program. Figure 1 shows that these address the core and discipline-specific knowledge and skills, communication, enquiry skills, critical thinking, problem solving, self-management, social responsibility and global citizenship which are governed by the UTAS graduate quality statement policy (University of Tasmania, 2014).

The results of this study clearly indicate that there is a need for VET and higher education to be flexible in their course offerings, maintaining a close relationship with industry to promote skills transfer between the sectors. This will ensure that the education and training sector remains relevant in meeting the learning outcome needs of employers and ensure

consistent and quality education and training. A closer partnership between industry and education and training providers will create a culture of communication and collaboration, making it easier for industry skills needs to be met.

Several of the industries require employees who have skills across two or more disciplines and/or span several AQF levels. This need is being addressed in Tasmania through current and recent pathways projects (OLT projects: ID13-2984 *Engineering pathways for regional Australia: viable learning platforms built by knowledge partnering*[1], and ID12-2477 *Development of mathematics pathways for VET students to articulate to related higher education courses*[2]) and in particular the development of a new associate degree at UTAS which is being developed based on industry consultation. The new associate degree is a partnership between VET, higher education and industry which will improve industry-valued outcomes.

The results of this study indicate that there is an identified need for up-skilling and reskilling within the education and training sectors in order to remain current and industry relevant, especially where higher-level skills needs are emerging related to STEM industries. Interviews conducted with the manufacturing and maritime industries identified the need to improve the partnership between the trainers and employers and the necessary inclusion of industry-expert teachers in VET-delivered programs to ensure the skills demand for the future is met. Additional research is needed to understand how best education and training providers can work effectively with industry to address the skills needs of niche businesses in thin education and training markets.

Project Impact and Dissemination

Project Impact

The project impact has been mapped to the Impact Management Planning and Evaluation Ladder (IMPEL) model (Hinton, 2014).

1. Team members	• **Increased** collaborations and ongoing connections with the VET sector developed through this project. • **Continued collaboration** with the research team on a number of new proposals which have developed through working on this and previous OLT projects. Project team members have continued their research collaboration into cross discipline research higher degree supervision. • **Increased interactions and partnerships** formed with industry and VET members through this project
2. Immediate students	• The project partners **understand** the **manufacturing**, **advanced**

[1] See: http://www.olt.gov.au/project-engineering-pathways-regional-australia-viable-learning-platforms-built-knowledge-partnering

[2] See: http://www.olt.gov.au/project-development-mathematics-pathways-vet-students-articulate-related-higher-education-courses-20

		manufacturing and maritime industry skills needs and can **provide a pathway** for up-skilling and reskilling students for these and related areas • The **Associate Degree in Engineering** and other existing pathways are filling the gap between the diploma- and bachelor-level programs and providing the industry desired skills of the future • Industry is readily **retraining their staff** to meet the needs of the future
3.	Spreading the word	• The **dissemination** of this project will be **ongoing** after this project completes through conference attendance and publication
4.	Narrow opportunistic adoption	•
5.	Narrow systemic adoption	• The process of industry consultation for the identification of required skills has supported the increased **collaboration** between the tertiary education sectors and the manufacturing, advanced manufacturing, maritime/marine and related industries
6.	Broad opportunistic adoption	
7.	Broad systemic adoption	• VET **students and industry are better prepared** for the future with graduates possessing the required skills • Skills gaps in industry are **reduced** and **programs are developed that have better industry-valued outcomes**

Dissemination Activities

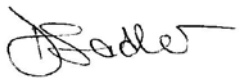
Dissemination has occurred throughout the entire project and below is a list of activities undertaken and planned.

- Dissemination of the project was communicated through consultation with industry during the interview process. The finalised report will be provided to the businesses involved in the project and the Tasmanian Maritime Network.
- Consultation meeting with TasTAFE and Skills Tasmania including sharing of industry participants, literature and findings.
- A peer-reviewed paper and conference presentation has been submitted to the Australasian Association of Engineering Education Conference. This conference is being held on 4–7 December 2016 and will be attended by the project leader, Associate Professor Irene Penesis.

Appendix A

Certification by Deputy Vice-Chancellor (or equivalent)

I certify that all parts of the final report for this OLT grant provide an accurate representation of the implementation, impact and findings of the project, and that the report is of publishable quality.



Professor David Sadler, DVC (Students and Education) Date: 26.05.2016

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Appendix C: Interview Schedule

Topic	Questions
Industry	1. Business Details Business Name: Contact Details: Address: Email: Phone: Company Website:
	2. Please describe the primary focus (core business) of your company/organisation.
	3. What year was your organisation established?
	4. How many people does your organisation employ?
	5. What is your annual gross turnover? a. Under $1 million b. Between $1 million and $1.5 million c. Between $1.5 million and $10 million d. $10 million and above
	6. What are your primary outputs/products and their share (percentage) of total output?
	7. Who are your key customers?
Current Skills	8. What skills and qualifications does your staff currently possess?
	9. What key skills and qualifications do you currently need your staff to possess?
	10. Have any of your current staff recently up-skilled or reskilled with either a VET or university qualification?
	11. How do you support staff who are currently doing training and/or higher education?
	12. Are staff rewarded for continuing their education and training?
	13. What other skills do you use/rely on from other supply chain companies?
Future Skills/Needs	14. What are the key areas of growth for your organisation over the next 3–5 years?
	15. Will your current staff have the skills required for these key areas of growth?
	16. What skills will be required by your staff to meet these areas of growth?
	17. Do you anticipate hiring to meet your organisation's future growth needs?
	18. If yes, approximately how many staff members?
	19. How will your organisation address skill shortages (especially with new technologies)?