Development of Mathematical Pathways for VET Students to Articulate to related Higher Education Courses

Final report 2015

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<www.utas.edu.au/mathematics-pathways/>
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Development of mathematical pathways for VET students to articulate to related higher education courses
List of Acronyms Used

ACARA   Australian Curriculum, Assessment and Reporting Authority
AQF     Australian Qualifications Framework
FU      Flinders University
HE      Higher education
MOU     Memorandum of Understanding
OER     Open Educational Resources
OLT     Office for Learning and Teaching
UNDA    The University of Notre Dame Australia
UTAS    University of Tasmania
VET     Vocational Education and Training
WCI     West Coast Institute
Executive Summary

This project developed an open educational resource (OER) to assist VET-qualified students to increase their mathematics skills and confidence in order to articulate to a related course in higher education. Four disciplines were examined: education, engineering, business and health science. The approach the project team took was to map the mathematics skills within the most commonly used VET qualifications that are used to transition into related higher education courses (e.g. the Diploma of Children’s Services to the Bachelor of Education – Primary and the Diploma of Engineering – Technical to the Bachelor of Engineering). The gap in the mathematics knowledge was determined and resources were identified and/or developed to fill the gaps. All four pathways were trialled with students.

Outcomes and Impacts

- A major learning of this project was that the mathematics gap is larger than anticipated with many VET qualifications containing little to no mathematics content in the units.

- An open educational resource (at www.utas.edu.au/mathematics-pathways) where all lessons and mathematics exercises (including practice quizzes) are free and accessible for the public to use.

- A Memorandum of Understanding (MOU) for the delivery of engineering programs was signed between TasTAFE and the University of Tasmania. The MOU allows for reverse articulation to be granted for completion of the mathematics pathway through transition units at UTAS and for credit to be received towards the student’s Diploma qualification.

- The pathways have been endorsed by The University of Notre Dame Australia’s School of Business, Fremantle Campus for students who have not completed pre-tertiary mathematics.

- Increased linkages between the VET and HE sectors and ongoing collaborations between project partners.

- Students have the flexibility to upskill using mathematics contextualised to their discipline in their own time using the online resource.

- The pathways are beneficial to all student user groups, not just VET students.
Recommendations
The project team makes the following recommendations:

- Using the model of the articulation agreement between TasTAFE and the University of Tasmania, expand the formal engineering pathways to South Australia and Queensland utilising project partner relationships.

- Develop formal articulation agreements for the education, business and health science pathways between the VET and HE sectors.

- Make pathways compulsory for students who do not have pre-tertiary mathematics to enable greater success for all students entering Bachelor degree programs.

- Re-examine the mathematics content in key VET qualifications.
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Introduction
Innovative economies require a workforce with strong technical and scientific awareness, however there is a decline in the number of students participating in pre-university science, technology, engineering and mathematics (STEM) worldwide (Noyes, Wake & Drake, 2011). Australia needs more qualified professionals in STEM but Australia’s graduation rates in STEM fields are low by international comparison (Office of the Chief Scientist, 2012). This is exacerbated in regional Australia where students are less likely to study subjects which are directly relevant to their regional economy (i.e. natural and physical sciences, engineering and agriculture (Richardson & Friedman, 2011)). The Australian government has aimed to increase participation in higher education to 40% of 25–34 year olds by the year 2025 and has a strong focus on STEM education (Office of the Chief Scientist 2012; 2014). One way to do this is to increase the pathways available to make higher education more accessible to students from a wide range of backgrounds, including those from a lower socioeconomic background (Wheelahan, 2009). Students from lower socioeconomic backgrounds tend to be underrepresented in higher education and in the upper levels of VET qualifications with only 20% of commencing students being from lower socioeconomic backgrounds (Wheelahan, 2009).

Australian post-secondary education is divided between the vocational education and training (VET) and higher education (HE) sectors. The two sectors differ in many ways, particularly in learning approach and student characteristics (Karmel, 2008), and this raises issues as a growing number of students move between the two sectors (Karmel, 2008; Watson, 2008; Moodie, 2012). Whereas VET learning is competency based, the university sector is knowledge based (Karmel, 2008). The sectors’ learning and teaching approaches and cultures are linked to the desired employment outcomes for the sector. The VET sector trains students for a particular skill and employment outcome whereas HE educates students for a contemporary, changing knowledge economy and emphasises independent study (Dawson, Charman & Kilpatrick, 2013). Utilising VET as a pathway to HE has recently generated growing activity around articulation pathways from VET and HE institutions (Bradley, 2008; Karmel, 2008; Dawson et.al., 2013).

This project addressed the need for greater participation in HE in STEM areas by creating contextualised online, open educational resources (OERs) for students to increase their mathematics skills in key areas. These resources developed in this project utilise a contextualised style of learning that VET-qualified students are familiar with and therefore enable them to fill the gap in their mathematics skills, build confidence and meet the requirements for their HE course.

Project Objectives
The objectives of this study for the areas of engineering, education, business and health science were:
• To identify HE courses and the related/pathway VET qualifications and map the mathematical skills and knowledge required for students to articulate successfully from particular VET qualifications into particular, related HE courses, ensuring AQF compliance.

• To develop, trial and evaluate mathematics pathway resources and tailored bridging programs for VET graduates articulating from particular qualifications into particular, related HE courses.

• Make the pathways and learning resources available online, including as OERs.

• To develop and support a community of practice amongst partner HE and VET institutions involved in the development and delivery of the mathematics pathways.

Project Approach
This project has adopted a cross-sectoral approach to improving pathways from VET to HE that focus on mathematical skill development. A substantial literature review was conducted in the first year of the project to understand the range of pathways available and key features of transitioning between VET and HE and mathematics education. The project developed online resources that build mathematics confidence through the use of contextualised, real-world problems. The use of contextualised learning is important to build on the competency based learning styles of VET students (Karmel, 2008). This allows VET students to learn in a familiar way whilst building their skills and confidence to make the transition to HE. All of the resources developed have been made available online as OERs. Each pathway discipline used an approach that suited the field and therefore each pathway is slightly different. Representatives of each discipline met initially over the phone or by Skype and then in person at one of two 2-day face-to-face meetings in Launceston, Tasmania to develop the approach for the pathway.

The project followed these steps to develop the pathway modules for each discipline:

• Identifying VET counterparts with which each university could partner.

• Identify which HE courses and VET qualifications (from the national training packages) were complementary and were most commonly utilised as a pathway. For example, the Diploma of Engineering was used as a pathway to the Bachelor of Engineering, and the Diploma of Children’s Services was used as a pathway to the Bachelor of Education (Early Childhood and Primary) respectively.

• Map the differences between the mathematical skills in the most common VET qualifications used as a pathway to related higher education courses.

• Determine the focus of the pathway – i.e. which skills were most important to cover and to what extent.
• Identify a range of mathematical resources that were free and accessible online that could be incorporated into a lesson and contextualised for the specific discipline.

• Develop the module materials.

The Pathways
This project examined four disciplines: engineering, education, health science and business. All four of these areas require a solid knowledge of mathematics for entry into their respective higher education courses. The gap in mathematics knowledge varies between what is taught in the VET qualifications and what is required for entry into the related HE course. However large or small the mathematics gap is, it should be stated that a significant gap in the knowledge does exist for all disciplines examined in this study.

Engineering
The Engineering Pathway undertook a comprehensive mathematical mapping of the VET mathematics units against the HE foundation units for the University of Tasmania, Flinders University and James Cook University, and against the Australian Curriculum Mathematical Methods unit (which is the most common pre-requisite for HE entry into engineering programs). This mapping clearly pointed out the gaps between the VET and HE sectors and what could be covered by existing resources at the partner universities. The mapping report is included in Appendix E: Mapping Report.

The approach taken by the Engineering Pathway was to develop a formalised articulation agreement between the VET and HE sectors. This occurred between TasTAFE and UTAS and will serve as a model for the other partner institutions. The articulation agreement is described in detail below and in the peer-reviewed paper, Penesis et al. (2014) (Appendix D).

The original aim of the Engineering Pathway was to ensure that students completing the pathway had equivalent mathematics knowledge to students who had completed the Australian Curriculum, Assessment and Reporting Authority’s (ACARA) Mathematical Methods as a pre-tertiary unit. This unit is considered a pre-requisite mathematics unit for university-level engineering bachelor degrees around Australia.

The engineering mathematics pathway articulation agreement between the University of Tasmania and TasTAFE was designed to sufficiently embed mathematics into the national training packages for VET AQF Level 5 qualifications to enable successful transition to a Bachelor of Engineering. The engineering group examined the VET qualifications most commonly used as a pathway to a Bachelor of Engineering at the partner universities. These qualifications included:

• ICT50210 – Diploma of Telecommunications and Networking
• MEM50105 – Diploma of Engineering – Advanced Trade
• MEM50212 – Diploma of Engineering – Technical
• MSA50108 – Diploma of Manufacturing Technology
• RII50509 – Diploma of Civil Construction
• UEE50111 – Diploma of Computer Systems Engineering
• UEE50411 – Diploma of Electrical Engineering
• UEE50511 – Diploma of Electronics and Communications Engineering

The pathway embeds, as electives, the VET mathematics units listed below where they do not already exist in the qualifications:

• MEM30012A – Apply Advanced Algebra and Numerical Methods to Engineering Tasks
• MEM23004A – Apply Technical Mathematics
• MEM23007A – Apply Calculus to Engineering Tasks

A comprehensive mapping of these units and partner universities’ foundations units against ACARA Mathematics Methods was conducted (Appendix E: Mapping Report) and gaps were identified between all the units.

Students have the option to enrol in the VET units above while they are completing their VET qualification. In Tasmania, the only qualification is MEM50212 – Diploma of Engineering – Technical. During this qualification, MEM23004A – Apply Technical Mathematics is a core unit and the additional two mathematics units can be added as electives. Unfortunately, these VET units are not readily available throughout the VET community. The alternative option is for students who are currently enrolled in a VET qualification and are unable to access the above units to enrol in university foundation units which have been mapped against the VET units. These foundation units (KMA002 and KMA003 at the University of Tasmania, Math 1701 and Math 1702 at Flinders University and MA1020 and MA1000 at James Cook University) are generic in nature and are accessible to students in a wide range of courses. In addition to the foundation units, students are required to complete successfully the first three modules on the project website (Complex Numbers, 1st and 2nd Order Differential Equations and Partial Differentiation). Students will then receive credit towards their VET qualification for equivalent units (MEM23007A and MEM30012A). The remainder of the online modules align to the mathematics taught in the university foundation units and provide support, practice problems, additional help and a contextualisation of the mathematics to engineering.

Additionally, students who have previously completed their VET qualification, have another qualification or just need to increase their mathematics skills and confidence can access the open educational resource and work through the modules, gaining the mathematics skills necessary for entry to the Bachelor of Engineering. Each module has a quiz to test the topic
skills and provides feedback on each answer. Students are also pointed in the direction of additional resources and help for each topic.

**Education**

The Education Pathway determined that a Certificate 4/Diploma in Children’s Services and Certificate 3 or 4 in Teacher’s Aide or Teacher Support were the most relevant VET qualifications to map into the Bachelor of Education (Early Childhood and Primary). The mathematics content mapping between the relevant VET and HE courses revealed that a mathematics component did not exist in the VET qualifications. The pathway, therefore, focused on six important topics that are required for success in the Bachelor of Education (Early Childhood and Primary) and that were identified by the HE partner to be areas of difficulty for commencing students regardless of their pathway into HE.

The approach then focused on developing six mathematical modules (Place Value and Appropriate Computational Skills; Relationships between Fractions, Decimals, Ratios & Percentages; Basic Algebra; Measurement; Geometry; Data & Statistics). A mathematics pre-test (diagnostic test) was developed to advise students as to which modules they needed to complete and a self-assessed quiz followed each module. It was anticipated that students would not necessarily need to complete all six modules and that the pre-test would indicate where the student should focus their attention. Each module was designed to take no more than 20 hours and included big ideas of the topic, lessons of understanding, practice tasks and a self-assessment. Modules also included a section for extended thinking on the topic and a check of the topic’s understandings. Once the module was complete, a self-assessed post-test could be attempted by the students to confirm their learning. If the students passed with a 70% pass rate they would automatically be emailed a Certificate of Completion.

Each module uses resources that future teachers might include in their own teaching to familiarise students with some of the resources available to Early Childhood and Primary teachers. The modules also introduce students to some of the language used in HE education degrees.

**Business**

The Business Pathway group undertook a mapping exercise to fully understand what mathematics were taught in several VET units associated with business qualifications at Certificate 3, 4 and Diploma level. The mathematics competencies were mapped against foundation-level units offered at the University of Tasmania and the University of Notre Dame Australia with a particular focus on a Quantitative Methods unit offered at the University of Tasmania, BFA109 Introduction to Quantitative Methods. At the time the research was undertaken, the University of Tasmania required all students enrolling in any undergraduate business degree to have completed the Tasmanian Qualifications Authority (TQA) unit Maths Applied or equivalent preparatory course such as UPP075 Bridging Maths,
or to undertake BEA109 Introduction to Quantitative Methods as part of their degree. All students completing a Bachelor of Business or Economics are required to undertake BEA140 Quantitative Methods. The unit BEA109 Introduction to Quantitative Methods or its equivalent is a pre-requisite for undertaking BEA140.

The approach focused on developing maths modules which would support students during their VET qualifications with foundation-level skills, and fill the mathematics gap between VET and HE, as well as provide support to students during their first year of university through both of the Quantitative Methods units. The pathway developed has seven modules, two of which are at foundation level, three at transition level and two which provide resources for support through HE mathematics. The first five modules provide the necessary mathematics skills to complete an introductory quantitative methods unit or equivalent. The remaining modules have been designed to supplement students’ mathematics knowledge while undertaking a more advanced quantitative methods unit. The learning modules can be run as stand-alone modules or be used consecutively and will be useful to not only VET students transitioning to business degrees but for any student commencing a degree and who wants to ensure they have sufficient mathematics skills to successfully complete the required quantitative methods units at a university level.

For the first five modules, a pre-test was developed to test whether a student needed to complete the module, and a post-test (self-assessed) was developed to test the students’ knowledge after completing the module lessons, practice tasks and exercises. Successful completion of the module post-tests has been endorsed by the University of Notre Dame Australia’s School of Business for entry into the program for students without tertiary maths.

**Health Science**

The Health Science Pathway group examined not only the mathematics units available in VET qualifications that were used as pathways to university health science degrees but also reflected on the mathematics difficulties students experience in their programs from all modes of entry. The group determined that basic mathematics, chemical calculations, scientific notation and other mathematics specifically relating to health science were a challenge to all students, not just those articulating from VET qualifications.

The approach built upon the Education Pathway and focused on developing resources that would fill the mathematics gap from VET qualifications such as Laboratory Operations and Fitness. These resources would also provide contextualised support for students at the foundation level while completing their VET qualification as well as through their university course with detailed explanations and worked examples of more complicated mathematics.

The pathway contains eleven modules, with the first nine modules providing pre-tests and quizzes which comprise the pathway and fill the mathematics gap. The final two modules are designed to provide worked examples and support in health science.
Results of the Pathways

The mathematics pathways project website (www.utas.edu.au/mathematics-pathways/) is an open educational resource (OER) which houses the content of the pathways providing examples and practice (in the form of self-assessed pre- and post-quizzes). The individual pathways were made available in stages with the Education Pathway and the Engineering Pathway available from February 2014 and the Health Science Pathway and Business Pathway available from February 2015. The website has had good uptake, receiving over 18 000 unique views (Table 1). The Education Pathway has received the greatest use with overall 71% of the unique page views over the duration of the project (Table 1). This is also reflected in the number of students attempting the pre- and post-test (Table 2) and completing the research survey. The Education Pathway utilised a single pre-test for all six modules. It asked between five and eight questions per topic. After the initial trial of the pathway, the pre-test was understood to be too long as only 72% of the 305 students initiating the pre-test actually completed it. The pre-test was therefore made optional for students in subsequent semesters.

The Business Pathway and Health Science Pathway built upon this information and developed short pre-tests for each individual module. The Business Pathway took the pre- and post-test a step further and developed a bank of questions to be randomly used in both the pre- and post-tests and providing the student with a percentage rate of completion, allowing each participating university to set its own pass rate. The University of Notre Dame Australia’s School of Business has endorsed the use of this pathway for all students entering the programs through alternative pathways (i.e. without tertiary mathematics). The high usage of the pre-test reflects this, with the Business Pathway having 123 attempted pre-tests in the short window the pathway was available (22 February–1 May 2015) to trial.
Table 1. The number of unique views for the Mathematics Pathways website, www.utas.edu.au/mathematics-pathways/

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<th>Web pages</th>
<th>2014</th>
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<th>Total Unique Views</th>
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<td>Mathematics Pathways - Home</td>
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<td>380</td>
<td>1241</td>
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<tr>
<td>Overview of the Project</td>
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<td>82</td>
<td>255</td>
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<tr>
<td>Pathway to Education</td>
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<td>5777</td>
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<tr>
<td>Pathway to Engineering</td>
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<tr>
<td>Pathway to Health Science*</td>
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<td>Pathway to Business*</td>
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* The Health Science Pathway and Business Pathway were under development during 2014 and became publicly available from February 2015.

Table 2. Pre- and post-test usage for each pathway and the number of post-tests that students passed at an 80% pass rate.

<table>
<thead>
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<td>0</td>
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<tr>
<td>Pathway to Business</td>
<td>123</td>
<td>88</td>
<td>10</td>
<td>7</td>
<td>6</td>
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</table>

Project Outputs and Findings

Project Website

The project resources have been housed in a University of Tasmania website which can be accessed at www.utas.edu.au/mathematics-pathways/. This website is an open educational resource and all lessons and mathematics exercises (including practice quizzes) are free and accessible for the public to use. The website has been live since the outset of the project with the Education Pathway and Engineering Pathway becoming available in February 2014, and the Business Pathway and Health Science Pathway becoming available in February.
2015. Over 18 000 unique views of the website have occurred between February 2014 and April 2015.

**Linkages**

Key linkages have been formed as a result of this project. These include:

- A Memorandum of Understanding (MOU) for the delivery of engineering programs was signed between TasTAFE and the University of Tasmania (UTAS). The MOU allows for reverse articulation to be granted for completion of the mathematics pathway through transition units at UTAS and receive credit towards the student’s diploma qualification.

- MOUs between all project partners (HE and VET) with the University of Tasmania.

- Ongoing collaborations from project team members with a successful Office for Learning and Teaching (OLT) seed project, “Reskilling the manufacturing workforce and developing the capabilities for the future” following this OLT project.

- An endorsement of the Pathway to Business resource by the School of Business at the University of Notre Dame Australia. The OER is endorsed for all students commencing from non-traditional pathways into higher education.

The development of these linkages has added to the impact of the project. The collaborations between project partners has resulted in successful funding with the development of the OLT seed project built upon synergies between two projects that were led by the University of Tasmania, these being the current project and “Engineering pathways for regional Australia: Viable learning platforms built by knowledge partnering”. Higher education team members benefited from working closely with members of the VET sector, it enabled a better understanding of the sector. The Business Pathway team had very strong linkages with their VET sector partners which enabled the HE partners to understand the needs of VET students, and in the end designed modules that not only meet the needs of students transitioning to HE but also support the mathematics needs of students studying certificates and Diplomas within the VET sector.

**Project Learnings**

During the first year of the project, mapping of the mathematics in VET and HE related courses for education and engineering was undertaken and a literature review was developed. The learning from these activities shaped the development of the OER pathways. One of the initial surprises from the mapping of the mathematics was the lack of mathematics in the VET qualifications which occurred in both of the initial disciplines examined.

In education, the related VET qualifications held no mathematics units at all. The main qualifications examined were:
There is a wide array of VET qualifications that students can use as a pathway to a Bachelor of Education (Primary and Early Childhood), however the above provided a pathway for the majority of VET students entering education at the University of Tasmania in 2013. Other notable VET qualifications were:

- Trade Certificate (equivalent to Certificate III) Hospitality/Commercial Cookery
- Trade Certificate (equivalent to Certificate III) Hairdressing/Beauty Therapy

The lack of any mathematics content in these VET qualifications further highlighted the necessity for the Education Pathway. This, in conjunction with the usage of the Education Pathway with 71% of the total views, represents a large demand for mathematics pathways into Bachelor of Education programs.

In engineering, the mapping of the most common VET qualifications which provide a pathway to a Bachelor of Engineering (Appendix E) highlighted the large gap in the mathematics between a Diploma-level qualification and what is considered a required level of mathematics for success in the first year of the Bachelor of Engineering. The Diploma-level engineering qualifications require one core unit in mathematics and from the mapping report (Appendix E) the mathematics level was estimated to be equivalent to a Year 9/10 mathematics course. In some states, an Advanced Diploma is offered which includes additional mathematics equivalent to pre-tertiary mathematics. These additional units can be taken as electives for Diploma-level qualifications, however, depending on student numbers and staffing profiles, these are not always available. In Tasmania, the Advanced Diploma qualification is no longer available and leaves a significant mathematics gap between VET and HE. The Education Pathway that was developed here addresses this need.

From the literature review and discussions with the VET partners on the project, a major focus of the pathways was on contextualised learning for VET students. This allows students who are familiar with this style of learning to continue using practical learnings to build their mathematics skills and confidence. It also allows students to understand how and why mathematics is important in their chosen course and future career. The four pathways used contextualised learning in the OERs.

Having a large project team has had both its advantages and disadvantages. The initial project team began with 14 HE partners and 4 VET partners and, with the addition of the Health Science Pathway and Business Pathway, grew to 30 project partners from both VET and HE. The additional partners that were part of the Health Science Pathway and Business Pathway varied in their commitment to the project. This is unsurprising because they were not part of the original proposal and it is suggested as a learning from this project that partners are “on board” from the outset of the project to maximise their ownership of the
project. Having a large project team also has its advantages with a diverse group of individuals bringing a range of experience and ideas.

**Student Surveys**

The student surveys revealed that everyone who provided an evaluation of the Education Pathway was a current university student. Forty percent of students had a previous highest mathematics level of Year 10, another 40% of students had pre-tertiary mathematics. Students (71.4%) who had completed a survey about the Education Pathway indicated they would do further modules if they became available.

Students who have used the pathway provided mostly positive feedback on the student surveys, including an email from one student:

> I started on the website last night, wow everything is so easily explained! As expected I need to do a lot of modules but this site is written in plain language!
>
> I have now ‘got the bug’ and am busy downloading apps to practice times tables and simple addition and subtraction as I think that’s where I really fall down, I get things wrong even though I have worked them out correctly because I made an error in the calculation somewhere, not the method necessarily.

Additional comments to the question “What is the most important thing you learned while doing the modules?” include:

> “it’s actually quite simple”
> “a revision on things I studied back at school (over 10 years ago!)”
> “I didn’t know how to do algebra now I have an idea”
> “It is all relational”
> “yes” – to doing more modules if they became available.

Only two students stated that they would not do any further modules if they became available: one student was using the Engineering Pathway and the other the Education Pathway.

**Literature Review**

**Introduction**

Australian post-secondary education is divided between the vocational education and training (VET) and higher education (HE) sectors. The two sectors differ in many ways, particularly in learning approach and student characteristics (Karmel, 2008). This raises issues as a growing number of students move between the two sectors (Karmel, 2008; Watson, 2008; Moodie, 2012). Whereas in the VET sector learning is competency based, in the HE sector it is knowledge based (Karmel, 2008). The sectors’ learning and teaching approaches and cultures are linked to the desired employment outcomes for each sector.
The VET sector trains students for a particular skill and employment outcome while HE educates students for a contemporary, changing knowledge economy and emphasises independent study (Dawson et al., 2013). Utilising VET as a pathway to HE has recently been supported by the government (Bradley, 2008) and has generated growing activity around articulation pathways from VET and HE institutions (Karmel, 2008; Dawson et al., 2013).

In Australia, there has been increasing demand for skilled professionals in the areas of science, engineering and technology (Office of the Chief Scientist, 2012). One way to meet these industry demands is to increase the number of students pursuing higher education degrees in these areas. This also assists in meeting the goals of the Australian government. The previous government had a target to increase the participation of 25–34 year olds pursuing a higher education degree to 40% by the year 2025 (Australian Government, 2009).

VET pathways to higher education are well established in Australia (Moodie, 2010). By increasing the pathways available to students make higher education more accessible to those from a wide range of backgrounds, including lower socioeconomic background (Wheelahan, 2009; Moodie, 2010). Students from lower socioeconomic backgrounds tend to be underrepresented in higher education and in the upper levels of VET qualifications with only 20% of commencing students being from the lower socioeconomic backgrounds (Wheelahan, 2009). It has been shown that VET-qualified students are accessing the post-1992 (UK) and lower-ranking universities both in Australia and overseas (Hoelscher, Hayward, & Dunbar-Goddet, 2008; Abbott-Chapman, 2011; O’Shea, Lysaght, & Tanner 2012). Hoelscher et al. (2008) suggest that students with a VET qualification are often seen as disadvantaged and they tend to follow institutional pathways into the less prestigious and newer universities. This notion is also supported by Dawson et al. (2013) who suggest that HE staff presume VET-qualified students will not perform as well as traditional students based on their preparation for HE. However, there is conflicting evidence in the literature and there is also research that shows that a VET entry qualification does not hamper a student’s ability to successfully complete their HE studies. Langworthy, Johns, & Humphries (2011) have shown that VET-qualified students perform equal to or better than their traditional student counterparts across a range of disciplines and Bingham and O’Hara (2007) also show that students progressing from further education into Sheffield Hallam University in Early Childhood studies did as well as the traditional students.

The VET sector may provide the entry requirements to higher education and therefore serve as a pathway for students who would otherwise not meet the entry requirements for their chosen degree (Stanwick, 2006; Wheelahan, 2009; O’Shea et al., 2012). By obtaining a VET qualification, some credit towards a HE degree may be awarded (PhillipsKPA, 2006; Guthrie, Stanwick, & Karmel, 2011; Langworthy et al., 2011). Higher education institutions generally review transcripts on a student-by-student basis to arrange credit transfer. Dowling (2010) points out that for engineering there is such variability in the number of electives that a student can choose to make up their qualification, the result is that the suitability of the qualification as a pathway to HE also varies. Each higher education institution will have its
own requirements for the pathways, and pathways agreements need to be in place between HE and VET providers. These arrangements are not always transparent to the student and can lead to confusion for those trying to navigate this landscape.

One barrier for articulating VET graduates is having the mathematical background needed for their chosen course in HE. This can be especially challenging for VET students as it may be a number of years since they studied mathematics and there may not have been any mathematics in their VET qualifications. The Advanced Diploma of Children’s Services in the Australian VET sector, which can be used as a pathway to Bachelor of Education (Primary and Early Childhood) degrees, is an example of this. A review of information from Australian universities shows that it is one of the most common VET courses used as a pathway to a Bachelor of Education in Australia but it does not include a mathematics component. It is reasonable to expect that this often leaves the student with gaps in their mathematical knowledge. This is not a phenomenon which is limited to VET students. Mathematics readiness is a major issue facing all students, whether they are traditional school leavers, mature aged or VET students (Brown, 2009; Wilkes, 2010; Belward, Rylands, Matthews, Coady, Adams, & Simbag, 2011).

The importance of mathematics is receiving a great deal of attention both in Australia (Office of the Chief Scientist, 2012; Freeman, 2013) and worldwide (Breiner, Harkness, Johnson, & Koehler, 2012) as STEM (Science, Technology, Engineering and Mathematics) education is seen as essential to support the modern knowledge based economy (Abbott-Chapman, 2011). A number of occupations, such as teaching, business, health sciences, information technology as well as engineering and the traditional sciences rely on a sound foundation in mathematics (Freeman, 2013). These occupations are also identified as areas where there are skill shortages (Freeman, 2013) and where the government is interested in promoting growth (Office of the Chief Scientist, 2012). Mathematics spans across all of the STEM disciplines and underpins it (Rice, 2011).

Using the VET to higher education pathway seems to be dependent on the field of study. Over 50% of students studying banking and accounting used their VET qualification to gain entry into a higher education institution. Overall 32% of young students (<24 years) continuing on to further study (Stanwick, 2006) used a VET qualification for this purpose. The student population of VET-qualified articulants varies greatly (Round, Brownless, & Rout, 2012), many students are mature aged, studying part-time or through work arrangements. Students who transition to HE from the VET sector do so in a number of ways (Harris & Rainey, 2006) and it is not always the straightforward school to VET to HE, it often involves working and changing of disciplines (Harris & Rainey, 2006; King, Dowling, & Godfrey, 2011) which can delay a student’s progression into HE. Abbott-Chapman (2006) outlined a mosaic of student experiences from education to employment and highlights that an increasing number of students are following fragmented pathways to higher education. Many of these students are from lower socioeconomic backgrounds (Wheelahan, 2009) and
attaining a VET qualification may seem more achievable than higher education. The interconnection between VET and HE is essential to create a pathway for these students to progress their education (Abbott-Chapman, 2011). The aim of this review is to understand VET as a pathway to HE specifically in the areas of engineering and education, what challenges are associated with these pathways and what resources exist to assist students.

Issues for students transferring from VET to HE

There are a number of issues and concerns for both HE institutions and students regarding students transferring from VET to HE. From the perspective of the HE institutions, the main concerns are student retention, and operational aspects such as credit transfers and success rates of students (King et al., 2011). Retention rates have been shown to be much lower for students with a vocational background (King et al., 2011; Round et al., 2012) but there is conflicting evidence within the literature on this topic. Knox (2005) shows that retention rates are good in their VET ‘Next Steps’ transition program and Langworthy et al. (2011) showed that completion rates were the same for VET students when compared to other student groups. It is not only academic reasons which force VET articulants to withdraw from their studies, it is also financial and social reasons. Watson (2006) suggests that work/life balance is a significant barrier to successful completion of studies for students transitioning from VET to HE, and so flexible forms of delivery can be used to overcome this challenge. Many of these students are from lower socioeconomic backgrounds (Wheelahan, 2009) and the loss of income while pursuing their degree may also prevent completion (King et al., 2011).

Students find the transfer to HE from VET confusing and frustrating (Santos Laanan, 2007; O’Shea et al., 2012) and they need to learn the new environment prior to being able to succeed. Among areas that students have found to be challenging is the need for independent learning and critical thinking (Curtis, 2009; Aird, Miller, van Megen, & Buys, 2010; O’Shea et al., 2012; Laming & Kelly, 2013), higher expectations (Bingham & O’Hara, 2007; Curtis, 2009; O’Shea et al., 2012), larger class sizes, and lower contact hours (Wheelahan, 2008) that are expected at the university level. In addition, students need to adjust to a new educational system and social settings (Brandell, Hemmi, & Thunberg, 2008). This adjustment can be further confounded when students are awarded credit for their VET qualifications and are able to start their undergraduate degree in second year units, therefore missing out on the first-year introductory information (O’Shea et al., 2012). Students feel that they would not have succeeded at HE without the TAFE background but still found the HE experience to be confronting especially having gained credit and moving into some second year units (O’Shea et al., 2012). Laming and Kelly (2013) identified that the VET students who received credit and moved into second-year units were really first-year students struggling to make the adjustment to HE.

There is considerable literature documenting the difficulties of transferring between the tertiary educational sectors (Watson, 2006; Brandell et al., 2008; Curtis, 2009; Aird et al.,
2010; Dowling, 2010; Guthrie et al., 2011; King et al., 2011; Laming & Kelly, 2013). This research emphasises that students articulating to the HE sector from VET need specialised support programs (i.e. academic study skills, literacy and numeracy support), orientation to the HE culture of learning, and clear explanations of expectations. Because the landscape of articulation is so confusing, there is a need for clearer understanding of the process of articulation (Aird et al., 2010) and this needs to be apparent to students when they begin their VET qualification. The culture of the staff within both the VET and HE sectors needs to be more aware of the differences and similarities between the learning styles, values and expectations of the other sector (Watson, 2006; Bingham & O'Hara, 2007; Laming & Kelly, 2013).

Transfer rates from VET to HE

The literature on the subject of the number of students articulating from a VET qualification to HE reports dramatically differing numbers even within an Australian context (Karmel, 2008). Students commencing with a VET qualification range from 3–25% of the total first-year students (Watson, 2008). At the lower end of the range are the Group of Eight universities, and where enrolments are above 20%, the institutions were dual-sector universities offering both VET and HE degrees (Watson, 2008; Bandias, Fuller, & Pfitzner, 2011). These dual-sector universities are in an ideal position to increase the pathway development between VET and HE. On average, students with a VET qualification have been estimated at 7–10% of the commencing student population (Karmel, 2008; Langworthy et al., 2011; NCVER, 2013). Differences exist between the states in Australia, in 2012 the Northern Territory had 10.9% of students with a VET qualification articulating to university while Tasmania had 4.7% (NCVER, 2013).

VET courses have traditionally provided practical, applied and hands-on training and so these students are more likely to enrol in disciplines in the more applied areas in HE. Students are more likely to enrol in engineering and technology, business and administration and education at rates 1.5 times higher than other fields, however more students were enrolled in agricultural science or computer science than any other field (Hoelscher et al., 2008). The largest cohort to transfer from VET to HE was in the field of nursing at 22% of entering students, followed by education (13%), IT (12%) and engineering at 6% (Moodie, 2012). In Australia, the highest proportion of vocational students enrolled in HE was in information technologies, with 13% of VET students continuing on to HE, followed by health (9%), management and commerce (8%) and education (6%) (NCVER, 2013).

Higher education has become more accessible to the non-traditional student and there has recently been an increase in the numbers of mature-age and VET-qualified students articulating to HE (Watson, 2008). The University of Tasmania has a strong culture of VET-qualified students articulating to undergraduate degree programs. The number of students accepted into these programs has steadily increased from 2004–2011 and they represent
approximately 10% of commencing students (Langworthy et al., 2011). Of the VET students commencing at the University of Tasmania, 20% were enrolled in the Bachelor of Education.

Mathematics

It has been identified at a number of universities within Australia (Cuthbert & MacGillivray, 2003; Rylands & Coady, 2009; Skalicky, Adam, & Brown, 2010) and internationally (Selden, 2005; Newman-Ford, Lloyd, & Thomas, 2007; Brandell et al., 2008) that first-year students often lack the mathematical skills necessary to successfully make the transition to tertiary education. This is not a phenomenon associated only with VET-qualified or mature-age (i.e. non-traditional) students, this gap in knowledge is becoming more commonplace for all students (Brown, 2009). Many university programs have lowered their pre-requisites to mathematics-based disciplines to accommodate the trend for secondary students to not take intermediate or advanced mathematics subjects (Jourdan, Cretchley, & Passmore, 2007; Brandell et al., 2008; Varsavsky, 2010). This creates a cycle where secondary students do not believe that mathematics is required for the course (Rylands & Coady, 2009; Belward et al, 2011) which allows for students to avoid studying mathematics at secondary school (Cuthbert & MacGillivray, 2003). This then results in an increasing number of students who do not have the necessary skills to undertake their chosen course and the need for universities to have bridging units in mathematics (Belward et al., 2011).

General (non-discipline specific) mathematics bridging or foundation units are offered at universities worldwide (specialised bridging courses/pathways are detailed below). There are conflicting results in the literature as to whether they solve the problems of mathematics readiness for first-year undergraduate students. Boland (2002) describes the bridging program at the University of South Australia and its overwhelming success. Over 70% of students in their bridging unit continued on to study at the university and a significant positive correlation (r=0.494, p<0.01) existed between their bridging unit marks and their undergraduate maths unit marks (Boland, 2002). Monash University offers three introductory-level maths units to students with varying mathematics background (from none to advanced) and they have found that 33% of students with little to no maths background succeed with high marks and often engaged in further mathematics studies (Varsavsky, 2010). These students progressed at the same rate as students with an intermediate level of maths background (Varsavsky, 2010). This is in contrast to the University of Western Sydney where the bridging units have not solved the mathematics readiness issue (Rylands & Coady, 2009). One reason may be the length of the bridging units. Many are over a period of 1–2 weeks immediately prior to the start of the semester and, for lack of a better term, cramming a years’ worth of mathematics learning into an intensive study period is insufficient for real comprehension of the topics (Rylands & Coady, 2009). However, there is a gap in the literature which tests this theory. Many universities have also implemented diagnostic testing (Heck & Van Gastel, 2006; Jennings, 2009; Rylands...
& Coady, 2009) to accurately understand the wide range of student mathematics abilities and backgrounds in order to strategically support first-year students.

One aspect that needs to be considered when examining mathematics preparedness is “maths anxiety” (Maloney, Schaeffer, & Beilock, 2013). Mathematics anxiety is a physiological response to mathematics and can begin as early as primary school but usually begins sometime during secondary school (Maloney et al., 2013). It can affect career and study choices, inclining students towards disciplines which are light in mathematics (Sheffield & Hunt, 2006). Many students with mathematics anxiety will avoid mathematics altogether. Of particular concern for our research, when mathematics skills are not regularly used, it can also lead to anxiety (Mackenzie, 2002) and this is important to acknowledge when teaching non-traditional students (i.e. adult learners) who may not have studied mathematics for many years (Galligan & Taylor, 2008; Berghella & Molenaar, 2013).

Flexible Learning and Delivery

There has been an increase in the use of flexible delivery in tertiary education over the last 20 years (Smith, 2000; Misko, Choi, Hong, & Lee, 2005; Todhunter, 2013). Differences exist in the way the terms “flexible”, “learning” and “delivery” are interpreted between the VET and HE sectors (Evans & Smith, 1999). In the HE sector these terms typically refer to the “relaxing or removal of place and time constraints in the educational experience”, while in the VET sector these terms are indicative of “client control, not just over the time and place of learning, but over what is learned, and the pace at which it is learned” (Smith, 2000). Client control is generally referring to an industry or an enterprise, however it can also represent the learner (Evans & Smith, 1999). The 2012–2015 National VET E-learning Strategy is focusing on supporting the learner pathways as a way to move from the VET sector to HE (Australian Government, 2012). Due to the flexible nature of e-learning it is important that it is engaging for both the student and teacher and that it is motivating for the student to continue to engage with this style of learning (Misko et al., 2005). Using contextualised learning helps to motivate students in an online environment (Misko et al., 2005; Inayat, Amin, Inayat, & Salim, 2013) and this is particularly important for students from the VET sector who have traditionally learned through applied learning.

The use of technology to teach mathematics in tertiary education is increasing and is also receiving positive feedback from both educators and students (Harrison, Pidcock, & Ward, 2009; Adams, Elliott, & Dekkers, 2010; Mahamad, Ibrahim, & Taib, 2010; Wilkes, 2010). The use of screencasts has been used in Australia and the UK to supplement undergraduate mathematics teaching (Wilkes, 2010; Loch, Jordan, Lowe, & Mestel, 2013). Students enjoyed the screencasts and felt that they were useful tools to understand more complex mathematical topics. Adams et al. (2010) describe the introduction and use of tablet PCs in the Mathematics Learning Centre (MLC) at Central Queensland University which have been instrumental in their transition mathematics program. They used the tablets to create personalised feedback videos for distance students as well as instructional videos with
worked examples for the entire unit. The overwhelmingly positive feedback from students on the use of the tablets has expanded their use to the Academic Learning Centre and the Engineering Department. Similarly, Harrison et al. (2009) use tablet PCs to deliver narrated lectures designed to be listened to prior to the live lecture and as support and revision for the mathematics units within the HELM (Helping Engineers Learn Mathematics) project. This project also used electronic voting during lectures to engage the student with the lecture material and to provide live feedback during the lecture. These uses of technology have proved to be valuable learning tools. There is a lack of literature describing specific uses of technology for teaching mathematics in the VET sector. Future research could focus on this area to examine how specific technologies can be used to deliver contextualised mathematics for different disciplines.

Existing Pathways

It is not uncommon for higher education institutions worldwide to have a mathematics bridging program for students (Boland, 2002; Cuthbert & MacGillivray, 2003; Newman-Ford et al., 2007). These are delivered in a number of different ways, the most common being as structured foundation units, however some departments have opted for speciality tutorials for specific cohorts of students (Oates, Paterson, Reilly, & Statham, 2005) and online units (Egea, 2004; Harrison et al., 2009). Some programs are tailored for specific cohorts of students (e.g. first-year engineering students) while others are more general (Newman-Ford et al., 2007). Students who have articulated from the VET sector have been part of a learning culture which is applied and contextualised. It is essential that a smooth transition occurs in the learning approach of these students to ensure success in the HE sector. To do this, specialised bridging programs which use contextualised learning are important for the success of these students. The following section presents examples of successful specialised maths bridging programs that focus on the areas of education and engineering.

Education

The University of Auckland has a range of mathematics programs to support undergraduate students, described by Oates et al. (2005) as a collaborative tutorial program between the Department of Mathematics and the Education Department. This tutorial program has students from the Graduate Diploma in Education (secondary) specialising in mathematics teaching, acting as tutors in an entry-level mathematics unit. This serves two functions to the student teacher: 1) to consolidate their knowledge of mathematics in order to provide support to the first-year undergraduate students and 2) to determine if they enjoy teaching as a career. The Graduate Diploma students are enrolled in a support unit simultaneously and in this unit they have a lecturer available for support and can discuss any teaching issues and experiences. This program is very successful with over 70% of the undergraduate mathematics students wanting these small tutorials and the student teachers learning a great deal from being able to refine their teaching practice. It should be noted that teachers
who are capable and comfortable with maths are more likely to empower their students to be capable and comfortable maths learners.

*Engineering*

Due to the wide range in mathematics ability of first-year students, the Queensland University of Technology (QUT) developed the Mathematics Access Centre (MAC) to increase the confidence and success in first-year engineering and mathematics students (Cuthbert & MacGillivray, 2003). The MAC runs three different types of help sessions: an enabling tutorial, exam workshops and a drop-in centre. The combination of these “promote an enviroinment of fellowship in learning” (Cuthbert & MacGillivray, 2003). This program has been extremely successful for QUT with up to 90% of students who used the MAC passing their first-year units and a significant decrease in the failure rates for second-year mathematics units (Cuthbert & MacGillivray, 2003).

The HELM (Helping Engineers Learn Mathematics) project based at Loughborough University is a consortium of five UK universities using flexible learning to improve the teaching of mathematics to engineering students (HELM, 2006). This program started in 2002 to develop resources in the form of workbooks supplemented by web-based teaching (HELM, 2006). The most recent focus of the project is to use the emerging technology to deliver and enhance the mathematics program to students (Harrison et al., 2009). The HELM project has been trialled on over 6000 students and is registered for use at over 90 institutions (Harrison et al., 2009). The most recent technologies used by the HELM project are narrated lectures on a tablet, electronic voting systems for use during lectures and using Moodle (a course management system) to deliver material such as podcasts and self-assessed quizzes. The narrated lectures are designed to augment the traditional lectures; students listen to the narrated tablet lecture before the in-person lecture to familiarise themselves with the topic and free themselves from having to take notes during the lectures. This has resulted in the students being more engaged with the mathematics during the traditional lectures and has received positive feedback from staff and students alike (Harrison et al., 2009). The HELM project is in the final process of making their resources *open source* to institutions outside the UK (A. Palipana, personal communication June 21, 2013).

Newman-Ford et al. (2007) describe the Bridging Technology with Mathematics program at the University of Glamorgan. This program, which was designed for engineering students over a six-week period, was module based and offered an alternative pathway for students into the undergraduate degree who did not have the mathematics pre-requisites. The program replaced a one-year foundation program and emphasised practical applications of mathematics, therefore being relevant to beginning engineering students. The Bridging Technology students were more prepared for their first-year studies and achieved on average nearly 9% higher than on their first-year assessments. This program has been
successful in preparing students for HE and increasing their competence and confidence in mathematics.

The University of Queensland has recently established a support program for first-year engineering students (Hillock, Jennings, Roberts, & Scharaschkin, 2013) where students attend weekly 1-hour tutorials. The aim of this program is to address the gaps in the background knowledge of students, provide mathematics support for students and increase the proportion of students passing their subjects for students who were at risk of failing. For students who regularly attended the program, the pass rate for first-year mathematics was 79% compared to a pass rate of 43% and 46% for students who occasionally attended or who did not attend the program, respectively. In addition, the pass rate of 79% was higher than that of non-at risk students which was 76% (Hillock et al., 2013).

Conclusions

It is clear from the literature that the landscape of pathways between the VET and HE sectors is not straightforward, and is therefore difficult for students to navigate. The learning outcomes of each sector are essential for a modern economy (Abbott-Chapman, 2011; Puukka, 2012) and the sectors have different educational purposes, and very different educational cultures. Nevertheless, the economy will benefit from individuals who can navigate the cultural divide and emerge with qualifications from both sectors.

Mathematics is a massive barrier for students progressing from the VET sector to HE. The importance of having a strong foundation in mathematics cannot be understated; it is important in many fields and can provide the basis for future study. To enable students from the VET sector to progress to HE, providing pathways which are applied and contextualised is essential. Students from the VET sector have experienced learning in an applied setting and continuing this style of learning is important especially during the transition period which can assist in a smoother change.

There is a need for flexibility and to address learning strategies to adult learners. Students making the transition from VET to HE may have competing pressures on their time and ensuring that a flexible option exists for them to continue their study is essential. Using emerging technologies has been a focus in the teaching of mathematics in the HE sector, however there is limited research on these technologies being used in VET.

There are a number of existing pathways for mathematics teaching and support for engineers worldwide, however we found very few examples directed towards the teaching of mathematics for education students. These specialised programs for specific cohorts of students have very positive results and provide the directed support the student requires. This supports our view that pathways need to be contextualised and focused in order to prepare VET students with the knowledge to succeed in higher education.
Project Impact, Dissemination and Evaluation

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
   - Recognition through continued research with project partners, the engineering group is a good example with an ongoing project for 2015/2016 of an OLT seed grant which stemmed from this mathematics pathways project

2. Immediate students
   - Students in the four discipline areas are more prepared for their higher education course from using the online resource
   - Students in engineering have a structured pathway from VET to higher education in Tasmania which is serving as a model for other states
   - Students have the flexibility to upskill using contextualised mathematics to their discipline in their own time using the online resource
   - The pathways are beneficial to all student user groups not just VET students

3. Spreading the word
   - The Mathematics Pathways website has been featured and disseminated through the FYiMaths (First Year in Maths) website
   - The Business Pathway online resource has been endorsed by the University of Notre Dame Australia’s School of Business
   - The engineering pathway was published in a special issue of the IJISMA journal focusing on mathematics preparation for STEM fields in tertiary education
   - The website has been viewed over 18,000 unique times
   - The engineering pathway has been incorporated into an articulation agreement between TasTAFE and UTAS
   - An updated online resource to support VET students in STEM fields to increase their mathematics skills
   - Materials used to support students from the VET sector making the transition to HE
   - The pathways project has been presented at five national and international conferences

4. Narrow opportunistic adoption
   - Students are able to increase their mathematics skills and confidence
   - Students continue to learn in a familiar/contextualised format while transitioning to university

5. Narrow systemic
   - Better collaboration between the tertiary education sectors to share
6. **Broad opportunistic adoption**

7. **Broad systemic adoption**

- **Inter-university development of resources**
- **VET students are better prepared** in mathematics for transitioning to higher education courses

**Dissemination Activities**

Dissemination has occurred throughout the entire project and below is a comprehensive list of activities undertaken. These dissemination activities have been crucial to achieve the impact the project has attained.

Conference presentations:

- **Australian Conference on Science and Mathematics Education**, Canberra, 19–21 September 2013, Presented by R. Barnes (UTAS).
  

- **Teaching Matters**, University of Tasmania 28–29 November 2013, Poster Presentation.
  

  

  
Peer-reviewed publications:


Newsletters and online dissemination:

- The Tasmanian Council for Adult Literacy published an article on the project in their November 2013 newsletter
- FYiMaths website posted an article on 27 February 2015: Mathematics Pathways for VET students – New Online Courses

**Evaluation**

The project evaluation contributed to the impact of the project through the set-up of the plan, the online evaluation of the web resource and the evaluation of the project team members.
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.

Name: ___________________________ Date: 24/6/15
Appendix B: References


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Appendix C: Evaluation Report
In this project HE and VET institutions will partner to develop a series of mathematics pathways designed to improve readiness for HE study, providing credit where appropriate.

Evaluation Final Report

*Development of mathematics pathways for VET students to articulate to related higher education courses*

Belinda Tynan
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Executive Summary

The Office of Learning and Teaching funded project “Development of mathematics pathways for VET students to articulate to related higher education courses” commenced in January 2013.

The main partners and stakeholders in the project included the University of Notre Dame, WA – West Coast Institute, James Cook University & Tropical North Queensland TAFE, Flinders University & TAFE SA partners and UTAS – TasTAFE.

The aim of the project was to develop a series of mathematics pathways designed to improve readiness for higher education study, providing credit where appropriate and compliant with the Australian Qualifications Framework (AQF). The modules sought to include the following underlying mathematics concepts,

- Maths knowledge and understanding necessary to complete studies meeting the minimum business degree entry requirement, and
- Knowledge and understanding needed to complete first year quantitative methods.
- To address confidence; how to recognise your own skills gap and what to do about it.

This evaluation report focuses on:

a) processes of the grant (how the project was implemented); and
b) the products/outcomes of the grant (intended and unintended as available)

Overall

Deliverables and outcomes as stated in the project plan have been achieved to a high level. Project management of the project has been undertaken professionally Working across UTAS schools, faculties and campuses has increased awareness between partners and is an unintended outcome and benefit.

Analysis of data is included in the report in later sections which provides further insight into the project processes and products.

Belinda Tynan
Evaluator
Introduction

The Office of Learning and Teaching funded project “Development of mathematics pathways for VET students to articulate to related higher education courses” commenced in January 2013.

The main partners and stakeholders in the project include the University of Notre Dame, WA – West Coast Institute, James Cook University & Tropical North Queensland, Flinders University & TAFE SA partners and UTAS – TasTAFE.

Goals

Between the partners the aim has been to develop a series of mathematics pathways designed to improve readiness for higher education study. Specifically the aims were:

- To identify HE courses and the related/pathway VET qualifications and map the mathematical skills and knowledge required for students to articulate successfully from particular VET qualifications into particular, related HE courses, ensuring AQF compliance.
- To develop, trial and evaluate mathematics pathway resources and tailored bridging programs for VET graduates articulating from particular qualifications into particular, related HE courses.
- Make the pathways and learning resources available online, including as OERs.
- To develop and support a community of practice amongst partner HE and VET institutions involved in the development and delivery of the mathematics pathways.

The pathway modules were designed to be delivered flexibly. The project used a staged process of identification and mapping, development, implementation and review, and developed two pathway areas in year one in the areas of Engineering and Education and two additional pathway areas in year two of the project. The project group agreed in their action plan that the modules would include:

- Basic underlying mathematics concepts,
- Maths knowledge and understanding necessary to complete studies meeting the minimum business degree entry requirement
- The knowledge and understanding required to be successful in their first year of their higher education qualification.
- Address confidence; particularly in how learners recognise their own skills gap and what to do about it.
- Contextualised knowledge and understanding to bridge the maths gap for each discipline.
Purpose

The Evaluation Plan was approved in October 2013. Since, a range of milestones and activities have been monitored as agreed. This final evaluation report therefore serves to provide the project team with an overview of both the process and products themselves and is inclusive of formative and summative feedback drawn from the key stakeholders over the two and a half years of the project.

This report will therefore focus on:

a) processes of the grant (how the project was implemented); and
b) the products/outcomes of the grant (intended and unintended as available)

Audience

The key audience for this report is the Office of Learning and Teaching, the Project Steering Committee and the Project Manager.

Methods

A range of methods were identified to collate evidence. The approaches used for both the mid-way report and final reports are as follows:

- Survey of stakeholders midway and at the conclusion of the project
- Interviews of project advisory group (conducted by the project manager midway in the project)
- Peer review of literature
- Observations of meetings and other documentation
- Student data (provided by the project manager)

Limitations

As this is both a formative and summative evaluation methodology there may well be issues in regards to interpretation and generalizability of the evaluation findings. There are also potential threats to the reliability and validity of the evaluation design and instrumentation tools. All measures were taken to assure that any threats were minimized and discussed with the project Leader and the Steering Committee.
### Evaluation and methods matrix

<table>
<thead>
<tr>
<th>Evaluation Criteria</th>
<th>Key Questions</th>
<th>Evidence</th>
<th>Status</th>
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<tbody>
<tr>
<td>Identification of key themes and trends</td>
<td>• How effective has the literature review and search for existing resources been in uncovering key trends, experiences and preferences in relation to the design, adoption and delivery of mathematics programs and management of OERs?</td>
<td>1. Literature review (peer reviewed) &lt;br&gt; 2. Key trends identified &lt;br&gt; 3. Resources identified (no? quality resources and identification of gaps - there will be gaps and we will be concentrating on places where there are few appropriate resources, so a large no. is not necessarily good!)</td>
<td>Completed</td>
</tr>
<tr>
<td>Effectiveness of project processes</td>
<td>• How effective was the project in engaging both VET and HE institutions? &lt;br&gt; • What changes/amendments need to be made to ensure the project meets its intended aims? &lt;br&gt; • Were there any variations from the processes that were initially proposed, and if so, why? &lt;br&gt; • What unintended benefits accrued from the project? &lt;br&gt; • What factors helped/hindered in the achievement of the outcomes?</td>
<td>Identify lessons that have been learned from this project and how might these be of assistance to other institutions, researchers and decision-makers interested in for adopting, using and managing mathematics pathway programs within their institutions.</td>
<td>Survey complete &lt;br&gt; Interviews &lt;br&gt; Observation of documentation &lt;br&gt; Attendance virtually at meeting in July 2013</td>
</tr>
<tr>
<td>Timeliness</td>
<td>• Were timelines managed</td>
<td>Ongoing monitoring of risk plan</td>
<td>Updates provided</td>
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appropriately?
• What strategies were in place for risk management?

On budget
• Did the budget describe accurately the extent of time required to undertake the project?

Ongoing monitoring

Documentation provided

**Activities**

<table>
<thead>
<tr>
<th>Timeframe / Step</th>
<th>Activities</th>
</tr>
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<tbody>
<tr>
<td>2013</td>
<td>Project establishment</td>
</tr>
<tr>
<td></td>
<td>Project Manager appointed</td>
</tr>
<tr>
<td></td>
<td>Agreements signed</td>
</tr>
<tr>
<td></td>
<td>Completed</td>
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<table>
<thead>
<tr>
<th>Timeframe / Step</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan- June 2013</td>
<td>Project Manager commences duty and project implementation (including development of project documentation)</td>
</tr>
<tr>
<td></td>
<td>Overall work plan and communication protocols for leadership and project teams agreed</td>
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<tr>
<td></td>
<td>Advisory group formed, terms of reference and communication protocols completed</td>
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<tr>
<td></td>
<td>Website established and activity initiated</td>
</tr>
<tr>
<td></td>
<td>Communication plan agreed</td>
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<tr>
<td></td>
<td>Evaluation plan developed and approved by SC October 2013</td>
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</tbody>
</table>

**Indicators & Milestones**

**Evaluation Actions & Deliverables**
<table>
<thead>
<tr>
<th>Date</th>
<th>Activity Description</th>
<th>Evaluation Plan Developed</th>
<th>Initial Engineering and Education Pathway Courses and VET Qualifications Identified</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jun-October</td>
<td>Literature Review Ethics Application Mid-Year progress Report</td>
<td>Ethics approved</td>
<td>Lit review completed</td>
</tr>
<tr>
<td></td>
<td>Evaluate, review and revise pathway packages with Advisory group, project evaluator input</td>
<td></td>
<td>Peer review of literature review undertaken by evaluator.</td>
</tr>
<tr>
<td>2013-2014</td>
<td>Identify and map initial Pathway courses and VET qualification</td>
<td>Detailed pathway work plans developed and agreed upon</td>
<td>Review pathways documentation (Action Plans, Health Science Pathway, mathematics mapping)</td>
</tr>
<tr>
<td>Mapping</td>
<td></td>
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<tr>
<td>October-2013</td>
<td>Developing learning pathways and prepare new learning resources as required</td>
<td>Pathways and resources developed Professional development delivered</td>
<td>Survey based on Formative Evaluation Questions Meeting recorded Engineering and Education pathways on website Trial agreed: UTAS – undergraduate students in the first year of study; JCU – students in the numeracy refresher course; UNDA/WCI – students at WCI finishing or nearly finishing their Diploma level qualification</td>
</tr>
<tr>
<td>March 2014</td>
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<tr>
<td>Jan-</td>
<td>Trail initial pathway packages. Evaluate, review and revise pathway packages with Advisory group, project evaluator input</td>
<td>Packages trialed in 2/3 institutional partnerships Pathways and resources revised in light of evaluation</td>
<td>Institutional survey results received</td>
</tr>
<tr>
<td>September</td>
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<tr>
<td>2014 Development 1(part 2)</td>
<td></td>
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<tr>
<td>Date Range</td>
<td>Activity Description</td>
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| March-December 2014 Development 2 (part 1) | Additional pathway areas  
Map pathway requirements  
Develop learning pathways, identify suitable existing resources and prepare new learning resources as required  
Develop facilitator’s guide  
Deliver Professional Development for tutors/facilitators who will run the trials |
| October 2014 –May 2015 Dissemination | Edit initial pathway materials and learning resources. Place on Website and OER repository.  
Commence Project report  
Write and present conference and journal papers |
| June 2015                     | Final Evaluation Report                                                                                                                                  |
Project results

Project processes
Two surveys were administrated during the course of the project. The first was created and released in January 2014, the second at the final stages of the project in May 2015.

Mid-way survey
The first survey received 9 total responses and 6 complete responses, of which all 9 responses gave their consent to partake in the survey. When asked if to their knowledge the stated milestones had been met and on schedule 6 participants responded with 50% agreeing, 33.33% strongly agreeing, 16.67% neither agreeing nor disagreeing, and no responses for disagreeing or strongly disagreeing. Of the 6 participants that responded to being questioned to the effectiveness of the project management 50% strongly agreed and 50% agreed.

When asked as a stakeholder that the participants felt that all stakeholders were engaged and clear on roles and responsibilities 6 participants responded with 66.67% agreeing, 16.67% strongly agreeing and 16.67% neither agreeing nor disagreeing with the statement. When asked about their awareness of interim milestones being met 6 participants responded with 66.67% agreeing, 16.67% strongly agreeing and 16.67% neither agreeing nor disagreeing that the milestones had been met.

In Question 6 the participants were asked if they were aware of and engagement with the dissemination plan, 6 participants responded with 50% agreeing, 16.67% strongly agreeing and 33.33% neither agreeing nor disagreeing that they were aware of and had engaged with the dissemination plan. When asked how the participants felt about the overall value of their participation and contribution to the community of practice, the scores were ranked as Medium (3.33), High (3.00), Low (2.50) and None (1.17).

The participants were asked whether any changes or amendments have needed to be made to ensure the project met it intended aims, this free text field was responded to by 6 participants. Two of the participants were not aware of any changes being made. The remaining 4 responded as follows:

“With engineering pathway pragmatic approach regarding development of online resources”
“Employment of people to do the writing of module material under supervision of team members has been essential”
“Involvement from ALL group members on the grant (not just delegated to a staff member in their school)”
“Being responsive and flexible”

When asked if the participants were aware of any unintended benefits being accrued across the project, the responses received were;

“Working across UTAS schools, faculties and campuses has been a great change”
“Strengthening links with other organisations. The engineering pathway is being embedded into a new Bachelor of General Studies (Engineering Pathway); this benefit was not originally envisaged”
“Links with colleagues in other institutions and across disciplines”
“Agreement with TasTAFE”
“Increased knowledge of partners both VET and HE”
“Raising the profile of maths in VET and the fact that you can develop maths skills later in your education”

In asking what factors were helping or hindering the achievement of the project outcomes, 6 responses were given;

“The physical separation between campuses in Tasmania is sometimes a disadvantage. Group video-conferencing does not replace face-to-face conversations”
“Synergy with team creating the UTAS Bachelor of General Studies (Engineering Pathway)”
“Project officer and employed writers are a major help”
“Not everyone is putting in the effort”
“None to my knowledge. It appears all is on track”
“The project team!”

In being asked of the activities the HE and VET partners have developed in regards to pathways resources to date, 6 responses were given;

“Mathematics resources with an engineering focus”
“Compulsory modules have been finalised and loaded onto website”
“See earlier”
“Mapping report – articulation document – signed agreement between TasTAFE and UTAS to trial pathway – online resources (both teams)”
“A number of resources to be used for transition of potential students in specialist areas”
“New resources for teacher education intending VET graduates a whole new way of working that has developed new options for engineering pathway students”

When asked if the partners had considered the implications of the AQF, the 6 responses received were;

“I don’t know”
“Have ensured that pathway is at appropriate AQF level”
“Yes”
“Throughout the project when designing the resources online and bridging between AQF 6 and 7 qualifications”
“I have not been involved in the development of the resources but I’m sure that partners have considered the levels within AQF in the development of resources”
“Fully aware of the implications”

The participants were asked to what extent the project team had included all of the topics that they and their potential students needed in the pathways. There were 2 responses stated that all was accounted for and the remaining 4 responses stated;

“The engineering pathway seeks to bridge the gap with pre-university mathematics. As a university academic my students are not in that category” [1a]
“The 6 modules cover all the key students’ needs”
“As I’m a VET rep it is difficult to answer this as the HE providers know the topics that are needed. They did however appear to be quite extensive!”
“Can’t comment”

When asked if there were any topics missing the responses received were either ‘no’, ‘N/A’, or ‘not aware of’, with one participant referring to the response they had given in the previous question (ref [1a]) and another stating “not missing but more/greater detail in the support of some ideas would be useful in the future”.

In the penultimate question the participants were asked whether the learning strategies take into account different students’ cognitive abilities. The responses received were;

“I have not thought about it”
“I’m not that familiar with the actual approach with the resources”
“Flexible learning environment, self-paced, students can use as they need”
“As I haven’t been involved in the development of the material it is difficult to comment. However the discussion focused on different learning styles and levels needed and to ensure the basics were covered adequately.”
“There is a standard to be reached, and there are in Education a number of steps that can be skipped for higher achieving students. For Engineering, students can progress in the units at their own pace.”

In the final question the participants were asked if they have any comments or concerns. Of the 4 responses received, 2 replied ‘No’ and the remaining two replied “that different project team members seem to have made quite contributions to the actual work that has been done” and “No just to reiterate that I have not undertaken any development as my role has been to provide VET context”.
Final Survey

The second survey received 10 total responses and 4 complete responses, of which all 10 responses gave their consent to partake in the survey. When asked if to their knowledge the stated milestones had been met and on schedule 4 participants responded with 75% agreeing, 25% strongly agreeing and no responses for disagreeing or strongly disagreeing. Of the 4 participants that responded to being questioned to the effectiveness of the project management 25% strongly agreed and 75% agreed.

When asked as a stakeholder that the participants felt that all stakeholders were engaged and clear on roles and responsibilities 4 participants responded with 50% agreeing, 25% neither agreeing nor disagreeing, and 25% disagreeing with the statement. When asked about their awareness of interim milestones being met 4 participants responded with 25% strongly agreeing, 25% agreeing, 25% neither agreeing nor disagreeing and 25% disagreeing that the milestones had been met.

In Question 6 the participants were asked if they were aware of and engagement with the dissemination plan, 4 participants responded with 50% agreeing, 25% strongly agreeing and 25% neither agreeing nor disagreeing that they were aware of and had engaged with the dissemination plan. When asked how the participants felt about the overall value of their participation and contribution to the community of practice, the scores were ranked as Medium (3.25), Low (2.75), None (2.25), High (1.75).

The participants were asked whether any changes or amendments have needed to be made to ensure the project met its intended aims, this free text field was responded to by 3 participants. One of the participants was not aware of any changes being made, another stating it was “N/A for engineering pathway”. The remaining respondent stated “The Education pathway was developed as intended. No changes were made to the original plans”.

When asked if the participants were aware of any unintended benefits being accrued across the project, two responses received were ‘none’ and the remaining response given was “The engineering pathway took the approach to formalise the articulation agreement between TasTAFE and UTAS. This was unanimously accepted by the team and partners as a successful approach”.

In asking what factors were helping or hindering the achievement of the project outcomes, 4 responses were given;

“Helping: collaboration between the tertiary education sectors to share resources. Hindering: using the UTAS/TasTAFE example, our partners could be developing their articulations with their nominated VET providers – this is still to happen”
“People’s commitment to the project”
“Helping: Expertise of partners. Consistent and reliable project management. Shared commitment by the stakeholders to enable VET students to transition to HE. Hindering: The difficulty of developing a self-directed learning environment online for people who
probably disengaged with mathematics in school. Finding the right balance between telling learners what they need to know and giving them the opportunity to develop understanding of the fundamental concepts is not easy. The data collected has not allowed us to determine if that balance was achieved.”

“Lack of relevant expertise and actual leadership of the Project Leader.
Lack of expertise in mathematics or mathematics education of TAFE partners”

In being asked of the activities the HE and VET partners have developed in regards to pathways resources to date, 4 responses were given;

“The project resources have been housed in a University of Tasmania website which can be accessed at [www.utas.edu.au/mathematic-pathways/](http://www.utas.edu.au/mathematic-pathways/). This website is an Open Education Resource and all lessons and mathematic exercises (including practice quizzes) are free and accessible for the public to use. The Pathways to Engineering became available in February 2014.”

“Engineering edu were good”
“The planned maths pathways have been developed”

When asked if the partners had considered the implications of the AQF, the 4 responses received were;

“There has been consideration of the AQF in developing the engineering pathway”
“Good”

The participants were asked to what extent the project team had included all of the topics that they and their potential students needed in the pathways. There were 4 responses which stated;

“For the engineering pathway, we only needed to provide resources for the gaps identified in the mapping, but the engineering team has provided resources to the same standard for all topics in the mathematics pathway. Topics across the ACARA mathematical methods curriculum, and where required beyond into first year engineering (complex numbers, differential equations and partial differentiation).”

“All”

“In the Education modules, the basic foundation knowledge of the mathematics topics is covered. There is the potential to build on this and add more resources to provide the opportunity to apply the understanding development and to extend the range of topics covered. There is also the potential for the Education modules to underpin the mathematics knowledge needed to proceed in the Engineering and Business pathways”

“Reasonably well given resource constraints”

When asked if there were any topics missing all the responses received were ‘no’, with the additional feedback from three participants as;

“No – not within the duration/scope of this project”
“No. It covers what was intended. Yes, it does not extend to the full extent of the Australian Curriculum Mathematics”
“No, but coverage of topics could be deeper and more thorough”

In the penultimate question the participants were asked whether the learning strategies take into account different students’ cognitive abilities. One participant gave a ‘?’ and another gave a response of ‘Yes’. The remaining two responses received were;

“This has been addressed through the use of videos to set the context of problems and to demonstrate the application of the mathematics. Apps and instructional videos have also been used as well as examples given to support procedural knowledge development. The context of problems, particularly the statistics module is related to real contexts and use real data.”
“Resources are clearly and consistently structured”

In the final question the participants were asked if they have any comments or concerns. Of the 2 responses received, 1 replied ‘No’ and the remaining two replied;

“I wish people would contribute more – I felt Robin was unsupported and had to do a lot of the work herself on this project. Academics want it on their record, but aren’t always willing to put in the work.”
“The Education modules have the potential to be developed further and be connected more directly to content covered in Pre-degree mathematics units. The use of the modules by education pre-service teachers is a positive outcome; however, I am sure they would benefit from a more extended resource that starts to help them appreciate what is required to teach mathematics (pedagogical content knowledge). There are many topics in the Education, Health Science, and Business pathway resources that overlap and could be consolidated.”

Student Feedback Survey Results
The analysis revealed some interesting data regarding the use of the website. The student surveys for the education pathway were accessed by students as they completed each module and contained 17 questions. Therefore, answers correspond to the reviewed module not the entire pathway. The student surveys for the Business and Health Science pathways were set up in the same way (i.e. to be completed after each module) however there were no student responses to these surveys. The student survey for the engineering pathway had seven questions and was available from the Pathway to Engineering Home page http://www.utas.edu.au/mathematics-pathways/pathway-to-engineering.

Of the students that were surveyed 36 responses were gathered. Of the students that started the survey 8 responses were considered to be complete however all 36 students selected that they had read the information sheet for students and agreed to participate in the study.
When questioned which pathway that they took 28 selected Education, 2 selected Engineering and 6 did not provide a response. Of the respondents 5 had completed the survey in the Mathematics Pathway for Education, with 13 responding that they had not and 18 not providing a response.

Nine of the respondents confirmed that they were living in Queensland, 1 in New South Wales, 1 in Tasmania, 1 stated ‘Other’ and 24 did not provide a response. Eleven respondents confirmed that they were currently studying, 1 stated that they were not currently studying and 24 did not provide a response. Seven stated that they were studying at James Cook University (JCU), 3 at University of Tasmania (UTAS), 1 at Samtse College of Education and 25 did not provide a response. Of the courses that they were studying 4 had enrolled on the BA for Education (Primary), 3 on the BA Education, Early Childhood, 1 on the BA of Teaching (Primary), 3 on the BA Education, 1 on the BA for Applied Education and 25 did not provide a response. Of mathematics previously studied 4 confirmed Year 10 mathematics counted towards university entrance, 6 confirmed Years 11/12, 1 stated ‘general mathematics’ and 24 did not provide an answer.

When questioned to what extent did each of the modules they completed help them to understand the content 1 respondent selected ‘definitely not’ and 35 did not provide an answer. When asked to what extent did each of the modules they completed help them to understand the content with regards to Place Value and Appropriate Computational Skills 1 selected ‘definitely yes’, 2 selected ‘yes’ and 1 did not provide a response (4 students completed a survey for this module). When asked the same question with regards to Relationships between Fractions, Decimals, Rations and Percentages (9 students completed a survey for this module) 2 selected ‘definitely yes’, 2 selected ‘probably yes’, 3 selected ‘maybe’. When asked for Basic Algebra (5 students completed a survey for this module) 2 selected ‘definitely yes’, 3 selected ‘yes’. When asked for Measurement (5 students completed a survey for this module) 2 selected ‘definitely yes’, 1 selected ‘yes’, 1 selected ‘Maybe’ For Data and Statistics all 36 did not provide a response.

Eleven respondents confirmed that they would do further modules if they became available, 2 confirmed that they would not and 23 didn’t provide a response.

When asked what the most important thing that the student had learned whilst studying Place Value and Appropriate Computational Skills module two students responded with ‘relationships’ and ‘to be are of the decimal point and where it is place and the order of calculations’. When this question was posed for Geometry two students responded with ‘a revision on things I studied at school (over 10 years ago!)’ and ‘looking at shapes multi-dimensionally’. For Fractions, Decimals, Rations and Percentages the responses received were ‘little things to trigger memory to work out questions’, ‘improper fractions and how to simplify an equation’, and ‘it’s all relational’. When asked in response to the Basic Algebra module 3 students gave responses of ‘a general review’, ‘I didn’t know how to do algebra now I have an idea’, and ‘calculate it to the one pronumeral – always do the same to both sides, get ‘rid of’ one side of the equation’. Finally the respondents were asked the same question for
Measurements, two responses were received as ‘it’s actually quite simple’, ‘how to convert from mm-km’.

For Place value and Appropriate Computational Skills of the 4 responses 2 strongly agreed, and 1 neither agreed nor disagreed when asked whether the module was easy to start. Two strongly agreed and 1 neither agreed nor disagreed to whether the module was easy to work through. Two strongly agreed, 1 agreed, and 1 neither agreed nor disagreed as to whether there was a good introduction to the module. Two strongly agreed, and 1 neither agreed nor disagreed as to whether anything they needed to know before they started was explained to them. One strongly agreed, 1 agreed, and 1 neither agreed nor disagreed as to whether the module was engaging and kept their interest. One strongly agreed, 1 agreed, and 1 neither agreed nor disagreed as to whether the content in the module was relevant to their future career.

For Geometry of the 4 responses 2 agreed and 2 did not provide a response when asked whether the module was easy to start. Two agreed and 2 did not provide a response as to whether the module was easy to work through. Two agreed and 2 did not provide a response as to whether there was a good introduction to the module. Two agreed and 2 did not provide a response as to whether anything they needed to know before they started was explained to them. One agreed and 1 neither agreed nor disagreed, and 2 didn’t provide a response as to whether the module was engaging and kept their interest. Two agreed, and 2 didn’t provide an answer as to whether the content in the module was relevant to their future career.

For Percentages of the 9 responses 3 strongly agreed, 1 neither agreed nor disagreed, and 5 did not provide a response when asked whether the module was easy to start. Three strongly agreed, 1 neither agreed nor disagreed, and 5 did not provide a response as to whether the module was easy to work through. Two strongly agreed, 1 agreed, 1 neither agreed nor disagreed, and 5 did not provide a response as to whether there was a good introduction to the module. Three strongly agreed, 1 neither agreed nor disagreed, and 5 did not provide a response as to whether anything they needed to know before they started was explained to them. Two strongly agreed, 1 agreed, and 1 neither agreed nor disagreed, and 5 didn’t provide a response as to whether the module was engaging and kept their interest. Two strongly agreed, 1 agreed, 1 neither agreed nor disagreed and 5 didn’t provide an answer as to whether the content in the module was relevant to their future career.

For Basic Algebra of the 5 responses 1 strongly agreed, 3 agreed and 1 did not provide a response when asked whether the module was easy to start. Four agreed and 1 did not provide a response as to whether the module was easy to work through. One strongly agreed, 3 agreed and 1 did not provide a response as to whether there was a good introduction to the module. One strongly agreed, 3 agreed and 1 did not provide a response as to whether anything they needed to know before they started was explained to them. One strongly agreed, 3 agreed and 1 didn’t provide a response as to whether the module was engaging and kept their interest. One strongly agreed, 3 agreed and 1 didn’t provide an answer as to whether the content in the module was relevant to their future career.
For Measurement of the 5 responses, 1 strongly agreed, 1 agreed, 1 neither agreed nor disagreed, and 2 did not provide a response when asked whether the module was easy to start. One strongly agreed, 1 agreed, 1 neither agreed nor disagreed, and 2 did not provide a response as to whether the module was easy to work through. One strongly agreed, 1 agreed, 1 neither agreed nor disagreed, and 2 did not provide a response as to whether there was a good introduction to the module. One strongly agreed, 1 agreed, 1 neither agreed nor disagreed, and 2 did not provide a response as to whether anything they needed to know before they started was explained to them. One strongly agreed, 1 agreed, and 1 neither agreed nor disagreed, and 2 didn’t provide a response as to whether the module was engaging and kept their interest. One strongly agreed, 1 agreed, 1 neither agreed nor disagreed, and 2 didn’t provide an answer as to whether the content in the module was relevant to their future career.

For the Geometry of the 4 responses, 2 agreed, 1 neither agreed nor disagreed, and 1 didn’t provide a response as to whether the instructions for the learning activities were clear. Two agreed and 2 didn’t provide a response as to whether the students could see how the learning activities related to big ideas. One strongly agreed, 1 agreed, and 2 didn’t provide a response as to if the students felt they were encouraged to use different approaches to solve the problems or complete the learning activities and practice tasks. One agreed, 1 neither agreed nor disagreed, and 2 didn’t provide a response if the students were able to access the materials in the module. Two agreed and 2 didn’t provide a response as to whether the students could see the relevance of the activities they had been set.

For Percentages of the 9 responses, 1 strongly agreed, 1 agreed, 1 neither agreed nor disagreed, and 6 didn’t provide a response as to whether the instructions for the learning activities were clear. One strongly agreed, 1 agreed, 1 neither agreed nor disagreed and 6 didn’t provide a response as to whether the students could see how the learning activities related to big ideas. One strongly agreed, 2 neither agreed nor disagreed and 6 didn’t provide a response as to if the students felt they were encouraged to use different approaches to solve the problems or complete the learning activities and practice tasks. One strongly agreed, 2 neither agreed nor disagreed, and 6 didn’t provide a response if the students were able to access the materials in the module. One strongly agreed, 1 agreed, 1 neither agreed nor disagreed and 6 didn’t provide a response as to whether the module was laid out so it was easy to read, see or hear. One strongly agreed, 1 agreed, 1 neither agreed nor disagreed and 6 didn’t provide a response as to whether the students could see the relevance of the activities they had been set.

For Basic Algebra of the 5 responses 1 strongly agreed, 2 agreed and 2 didn’t provide a response as to whether the instructions for the learning activities were clear. One strongly agreed, 2 agreed and 2 didn’t provide a response as to whether the students could see how the learning activities related to big ideas. Two strongly agreed, 1 agreed and 2 didn’t provide a response as to if the students felt they were encouraged to use different approaches to solve the problems or complete the learning activities and practice tasks. One strongly agreed, 1 agreed, and 1 neither agreed nor disagreed, and 2 didn’t provide a response if the students were able to access the materials in the module. One strongly agreed, 2 agreed and 2 didn’t
provide a response as to whether the module was laid out so it was easy to read, see or hear. One strongly agreed, 2 agreed and 2 didn’t provide a response as to whether the students could see the relevance of the activities they had been set.

For Measurement of the 5 responses 2 agreed, 1 neither agreed nor disagreed and 2 didn’t provide a response as to whether the instructions for the learning activities were clear. One strongly agreed, 2 neither agreed nor disagreed and 2 didn’t provide a response as to whether the students could see how the learning activities related to big ideas. One strongly agreed, 1 agreed, 1 neither agreed nor disagreed and 2 didn’t provide a response as to if the students felt they were encouraged to use different approaches to solve the problems or complete the learning activities and practice tasks. One strongly agreed, 2 neither agreed nor disagreed, and 2 didn’t provide a response if the students were able to access the materials in the module. Two agreed, 1 neither agreed nor disagreed and 2 didn’t provide a response as to whether the module was laid out so it was easy to read, see or hear. Two agreed, 1 neither agreed nor disagreed and 2 didn’t provide a response as to whether the students could see the relevance of the activities they had been set.

**Web usage results**

For the web usage stats the data was gathered from February 2014 to April 2015, allowed for a fair representation for a year of data and comparison of the months February to April to 2014 and 2015 respectively.

During February – December 2014 the Mathematics homepage received 861 total unique views, the overview of the project received 173 total unique views, Pathway to Education received 1238 total unique views and Pathway to Engineering received 508 total unique views. The highest viewed pages were Place Value, Fractions, and Geometry with 1740, 1615, and 1607 total unique views respectfully. The Registration Form page received the lowest number with 20 total unique views, with the Compulsory Modules and both Supporting Modules pages receiving the lowest collective number of total unique subpage views.

In comparison of data from 2014 (February – December) and 2015 (January – April) whilst the 2015 year is not yet complete so therefore a number of pages for 2015 have yet to equal or surpass the 2014 data, the total unique views for Fractions has increased from 1615 in 2014 to 2539 to date in 2015.

For the comparative months of February – April 2014 and February – April 2015, the following total unique views were registered:

<table>
<thead>
<tr>
<th></th>
<th>February-April 2014</th>
<th>February-April 2015</th>
<th>Differential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematics Pathways</td>
<td>140</td>
<td>320</td>
<td>+180</td>
</tr>
<tr>
<td>Home</td>
<td>140</td>
<td>320</td>
<td>+180</td>
</tr>
<tr>
<td>Overview of the</td>
<td>66</td>
<td>75</td>
<td>+9</td>
</tr>
<tr>
<td>Project</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pathway to Education</td>
<td>215</td>
<td>243</td>
<td>+28</td>
</tr>
<tr>
<td>Place Value</td>
<td>309</td>
<td>1007</td>
<td>+698</td>
</tr>
</tbody>
</table>
Though the mathematics pathways have seen an increase on the home page and the
subpages, there has been a decrease in the number of total unique views of the Pathways
to Engineering and the Compulsory and Supporting Modules subpages.

Given the sharp increase in some of the Mathematics pathway subpages it would have
been expected for this increase to also be reflected in the Registration Form page which
only saw an increase of 5 total unique views.

So while the web analysis details that the total unique views are up across the board in
comparative months in 2014 and 2015 this doesn't seem to have impacted on the
registration form and the compulsory and supporting modules pages.
Appendix D: Journal Articles

Development of Mathematical Pathways for VET Students to Articulate to Related Higher Education Courses: a Focus on Engineering

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Keywords: mathematics, pathways, VET, engineering, STEM, Higher education, online learning


Abstract

Australia needs more qualified professionals in the Science, Technology, Engineering, and Mathematics (STEM) areas. The national focus on widening participation in higher education (HE) includes strengthening pathways from vocational education and training (VET). VET students often lack the mathematics skills necessary to articulate successfully to their chosen university degrees. Current approaches such as bridging and foundation mathematics programs are not tailored or sufficiently contextualised for VET articulants. This project is developing a mathematics pathway designed to improve the readiness of VET engineering diploma graduates for higher education study in engineering degree programs. Arrangements are flexible so that students can complete these pathways either as part of their engineering diploma as a VET student or as part of preparatory study at the diploma level at university.

Many VET students are granted credit when entering a HE course in engineering and can transfer directly to second year units which may assume a level of mathematical knowledge by the university. However, in the VET Diploma of Engineering Technical (MEM50212), there is only one core unit in mathematics (MEM30012A) equivalent to year 9 level and there are two mathematics electives, MEM23004A and MEM23007A, which are part of the advanced diploma and often not taught by many TAFE providers due to student demand and staff capabilities. The lack of required mathematics often leaves the student with a large gap in the required knowledge for success in HE.

The project has been underway for over a year and significant progress has been made in developing the pathway for engineering. To date, the mathematical knowledge outcomes from the VET courses have been mapped to the requirements of the HE courses at the University of Tasmania, Flinders University and James Cook University. Gaps in mathematical knowledge have been identified. A formal articulation agreement has been established through TasTAFE and the University of Tasmania where current VET students will be able to enroll in the university foundation mathematics units and receive credit towards their VET diploma in engineering. In addition to the foundation units, the students need to do an online component. This consists of a few compulsory topics which are not covered in the foundation units with supporting examples, practice
problems, practical application and self-assessed quizzes for each mathematics topic covered in the foundation units, contextualised to engineering. VET students are applied learners and therefore often struggle with the transition to HE. The online component of the pathway is designed to support the student by providing the context to the mathematics they are learning. Another advantage of the pathway is that it exposes the VET students to HE units and the university environment while satisfying the university mathematics entry requirements.

Introduction
Australian post-secondary education is divided between the Vocational Education and Training (VET) and Higher Education (HE) sectors. The two sectors differ in many ways, particularly in learning approach and students’ characteristics (Karmel, 2008), which raises issues as a growing number of students move between the two sectors (Karmel, 2008; Watson, 2008; Moodie, 2012). Where VET learning is competency based, the HE sector is knowledge based (Karmel, 2008). The sectors’ learning and teaching approaches and cultures are linked to the desired employment outcomes for each sector. The VET sector trains students for a particular skill and employment outcome while HE educates students for a contemporary, changing knowledge economy and emphasises independent study (Dawson, Charman and Kilpatrick, 2013). Utilising VET as a pathway to HE has recently been supported by the government (Bradley, 2008) and has generated a growing activity around articulation pathways from VET to HE institutions (Karmel, 2008; Dawson, Charman and Kilpatrick, 2013).

In Australia, there has been increasing demand for skilled professionals in the areas of STEM (Office of the Chief Scientist, 2012). More specifically, there is a shortage of engineering graduates from the HE sector (King, Dowling and Godfrey, 2011; Watson and McIntyre, 2011; Yu, Bretherton and Buchanan, 2013). One way to meet these industry demands is to increase the number of students pursuing higher education degrees in these areas. This also assists in meeting the goals of the Australian Government. The previous Government had a target to increase the participation of 25-34 year olds pursuing a higher education degree to 40% by the year 2025 (Australian Government, 2009). The government wants to increase the pathways available to make higher education more accessible to students from a wide range of backgrounds, including those from a lower socioeconomic background (Wheelahan, 2009).

The importance of mathematics is receiving a great deal of attention both in Australia (Office of the Chief Scientist, 2012; Freeman, 2013) and worldwide (Breiner, Harkness, Johnson and Koehler, 2012) as STEM education is seen as essential to support the modern knowledge based economy (Abbott-Chapman, 2011). A number of occupations rely on a good foundation of mathematics, such as teaching, business, health sciences, information technology as well as engineering and the traditional sciences (Freeman, 2013). These occupations are also identified as areas where there are skill shortages (Freeman, 2013) and where the government is interested in promoting growth (Office of the Chief Scientist, 2012). Mathematics spans across all of the STEM disciplines and underpins it (Rice, 2011).

Students from lower socioeconomic backgrounds tend to be underrepresented in higher education and in the upper levels of VET qualifications with only 20% of commencing students being from the lower socioeconomic background (Wheelahan, 2009). It has been shown that VET qualified students are accessing the post-1992 (UK) and lower ranking Universities both in Australia and overseas (Hoelscher, Hayward, Ertl and Dunbar-Goddet, 2008; Abbott-Chapman, 2011; O’Shea, Lysaght and Tanner, 2012). Hoelscher, Hayward, Ertl and Dunbar-Goddet (2008) suggests that a student with a VET qualification is often seen as disadvantaged and they tend to follow institutional pathways in to the less prestigious
Universities. This notion is also supported by Dawson, Charman and Kilpatrick (2013) who suggests that HE staff presume VET qualified students will not perform as well as traditional students based on their preparation for HE. However, there is conflicting evidence in the literature and there is also research that shows that a VET entry qualification doesn’t hamper a student’s ability to successfully complete their HE studies. Langworthy, Johns and Humphries (2011) has shown that VET qualified students perform equal to or better than their traditional student counterparts across a range of disciplines.

The VET sector may provide the entry requirements to HE and therefore serve as a pathway for students who would otherwise not meet the entry requirements for their chosen degree (Stanwick, 2006; Wheelahan, 2009; O’Shea, Lysaght and Tanner, 2012). By obtaining a VET qualification, some credit towards a HE degree may be awarded (PhillipsKPA, 2006; Guthrie, Stanwick and Karmel, 2011; Langworthy, Johns and Humphries, 2011). Many higher education institutions review transcripts on a student by student basis to arrange credit transfer and in the case of engineering, Dowling (2010) points out that because there is such variability in the number of electives that a student can take to make up their qualification, the suitability of the qualification as a pathway to HE also varies. Each higher education institution will have its own requirements for the pathways and pathways agreements need to be in place between HE and VET providers. These arrangements are not always transparent to the student and can lead to confusion for those trying to navigate this landscape. One way to address this is to form strong links between the VET and HE sectors with transparent agreements as done in the current study with the development of the engineering pathway in Tasmania.

Utilising the VET to HE pathway seems to be dependent on the field of study. Over 50% of students studying banking and accounting used their VET qualification to gain entry into a higher education institution and overall 32% of young students (<24 years) continued on to further study in Australia (Stanwick, 2006). The student population of VET qualified articulants varies greatly (Round, Brownless and Rout, 2012). Many students are mature aged, studying part-time or through work arrangements. Students who transition to HE from the VET sector do so in a number of ways (Harris and Rainey, 2006) and it is not always the straightforward, school to VET to HE, it often involves working and changing of disciplines (Harris and Rainey, 2006; King, Dowling and Godfrey, 2011) which can delay a student’s progression into HE. Abbott-Chapman (2006) outlined a mosaic of student experiences from education to employment and highlights that an increasing number of students are following fragmented pathways to HE. Many of these students are from lower socioeconomic backgrounds (Wheelahan, 2009) and attaining a VET qualification may seem more achievable than HE. The interconnection between VET and HE is essential to create a pathway for these students to progress their education (Abbott-Chapman, 2011).

One barrier for articulating VET graduates is having the mathematical background needed for their chosen course in HE. This can be especially challenging for VET students as it may be a number of years since they studied mathematics and there may not have been any mathematics in their VET qualifications. It is reasonable to expect that this often leaves the student with gaps in their assumed mathematical knowledge. This is not a phenomenon which is limited to VET students. Mathematics readiness is a major issue facing all students’ whether they are traditional school leavers, mature aged or VET students (Brown, 2009; Wilkes, 2010; Belward, Rylands, Matthews, Coady, Adams and Simbag, 2011).

It has been identified at a number of universities within Australia (Cuthbert and MacGillivray, 2003; Rylands and Coady, 2009; Skalicky, Adam and Brown, 2010) and
internationally (Selden, 2005; Newman-Ford, Lloyd and Thomas, 2007; Brandell, Hemmi and Thunberg, 2008) that first year students often lack the mathematical skills necessary to successfully make the transition to tertiary education. This is not a phenomenon only associated with VET qualified or mature age (i.e. non-traditional) students, this gap in knowledge is becoming more commonplace for all students (Brown, 2009). Many university programs have lowered their pre-requisites to mathematics based disciplines to accommodate the trend of secondary students to not take mathematics (Jourdan, Cretchley and Passmore, 2007; Brandell, Hemmi and Thunberg, 2008; Varsavsky, 2010). This creates a cycle where secondary students do not believe that mathematics is required for the course (Rylands and Coady, 2009; Belward, Rylands, Matthews, Coady, Adams and Simbag, 2011) which allows for students to avoid studying math at secondary school (Cuthbert and MacGillivray, 2003). This then results in an increasing number of students that do not have the necessary skills to undertake their chosen course and the need for each university to have a bridging unit in mathematics (Belward, Rylands, Matthews, Coady, Adams and Simbag, 2011).

General (non-discipline specific) mathematics bridging or foundation units are offered at universities worldwide (specialised bridging courses/pathways are detailed below). There are conflicting results in the literature as to whether they solve the problems of mathematics readiness for first-year undergraduate students. Boland (2002) describes the bridging program at the University of South Australia and its overwhelming success. Over 70% of students in their bridging unit continued on to study at the University and a statistically significant positive correlation ($r=0.494, p<0.01$) existed between their bridging unit marks and their undergraduate math unit marks (Boland, 2002). Monash University offers three introductory level maths units to students with varying mathematics backgrounds (none – intermediate – advanced), they have found that 33% of students with little to no maths background succeed with high marks and often engage in further mathematics studies (Varsavsky, 2010). These students progress at the same rate as students with an intermediate level of maths background (Varsavsky, 2010). This is in contrast to the University of Western Sydney where the bridging units have not solved the mathematics readiness (Rylands and Coady, 2009). One reason may be the length of the bridging units, many are only 1-2 weeks immediately prior to the start of the semester and, for lack of a better term, cramming a years’ worth of mathematics learning into an intensive study period is insufficient for real comprehension of the topics (Rylands and Coady, 2009). However, there is a gap in the literature which tests this theory. Many universities are also implementing diagnostic testing (Heck and Van Gastel, 2006; Jennings, 2009; Rylands and Coady, 2009) to accurately understand the wide range of student mathematics abilities and backgrounds in order to strategically support first-year students.

One aspect that needs to be considered when examining mathematics preparedness is ‘maths anxiety’ (Maloney, Schaeffer and Beilock, 2013). Maths anxiety is a real physiological response to mathematics and can begin as early as primary school but is usually set sometime during secondary school (Maloney, Schaeffer and Beilock, 2013) and can affect career and study choices towards disciplines which are light in mathematics (Sheffield and Hunt, 2006). Many students with maths anxiety will avoid maths altogether. Of particular concern for our research, when mathematics skills are not regularly used it can also lead to anxiety (Mackenzie, 2002). This is important to acknowledge when teaching non-traditional students (i.e. adult learners) who may not have studied mathematics for many years (Galligan and Taylor, 2008; Berghella and Molenaar, 2013).

The aim of this project is to develop contextualised mathematics pathways for VET students, designed to assist AQF compliance and articulate to related HE courses, in engineering,
education, business and health science. The pathways are designed to improve student readiness for HE study. This paper specifically describes the process undertaken to develop the mathematics pathway for engineering.

**Development of the Engineering Pathway**

**Engineering context**

The 2013 statistical overview by Engineers Australia discusses the engineering labour market (Kaspura, 2013). It suggests a slowdown in the recruitment of qualified engineers and problems experienced by employers following the recovery after the global financial crisis. Despite an apparent reduction in the demand, more than 30% of employers experience major problems, including project delays and costs because of difficulty in recruiting qualified engineers (Kaspura, 2013). Thus while there has been an easing in recent years in problems in recruiting, due to undersupply of qualified engineers, there is still a need for further graduates with engineering qualifications.

Engineers Australia is an organisation “established to advance the science and practice of engineering for the benefit of the community” (Kaspura, 2013, p. 1). The annual statistical report from Engineers Australia provides useful insight into the shape of the cohort of students who study engineering at university. In 2010 and 2011, roughly 11,000 year 12 students accepted a place in a university engineering course (Kaspura, 2013). By considering all enrolments in engineering courses we can gain some idea as to where these year 12 graduates study in the suite of offerings in engineering at university. Upon leaving secondary school the range of courses available include Certificates, Diplomas, Associate Degrees, Advanced Diplomas and Bachelor Degrees. In 2011, just over 13,000 domestic students commenced a Bachelor degree in engineering, while just over 2000 commenced associate degrees, advance diplomas, diplomas or certificates (Kaspura, 2013, table 5.3, p.29). These figures show that the minimum number of students who articulate from year 12 into a Bachelor Degree in engineering must be around 9000 out of the total cohort of 13,000. This minimum would be achieved if the entire cohort of students in Associate Degrees, Diplomas, Advance Diplomas and Certificates were from the cohort of those year 12 graduates from 2010 who accepted a place in engineering at university. The more likely scenario is that nearly all of the 11,000 year 12 students accepted a place into a Bachelor Degree, meaning that only about 2000 out of the roughly 13000 who commenced a Bachelor Degree did so on a pathway that was not directly from year 12. The statistics show that the dominant pathway in to bachelor degrees in engineering is direct, through completion of year 12 in secondary school. These statistics align with the comments made by King, Dowling and Godfrey (2011) who report that the majority of Australian students who enter bachelor degree programs do so directly from year 12 in secondary school.

The figures presented above are consistent with those in two earlier publications that analysed the relationship between VET and HE in engineering programs. These publications show the figure of six percent of commencing bachelor degrees in engineering articulating from VET courses (King, Dowling and Godfrey, 2011; Watson and McIntyre, 2011). One question that perhaps needs to be answered is: What is a reasonable rate of articulation from VET courses to bachelor degrees in engineering? An upper bound on the figure can be estimated by using figures in King, Dowling and Godfrey, (2011) showing that in 2008 almost 1800 domestic students completed VET diplomas in engineering and just over 1500 domestic students completed VET advanced diplomas in engineering. If we use figures from Kaspura (2013) showing domestic commencements in 2009 of approximately 12,000
students, we can see that the greatest possible contribution from the diploma and advanced diploma students is around 15 to 20%, with the variation arising from the fact that some diploma students will articulate to advanced diploma courses before proceeding to a bachelor degree, while some may articulate directly from diploma courses.

This analysis above suggests that there is scope to increase the number of students studying bachelor degrees in engineering through increasing the number of students articulating from VET courses. This is one of five strategies indicated by King, Dowling and Godfrey (2011) to increase the number of students studying bachelor degrees in engineering and is the strategy that is the focus of the project this publication discusses. This also helps to meets the goals of the Australian Government to increase the number of HE graduates by 2025 (Australian Government, 2009).

Of interest to this project are the success rates of students who articulate from VET programs to bachelor degrees in engineering. It is important that those students who do articulate have a reasonable chance of success in their chosen field. The study by King, Dowling and Godfrey (2011) reports findings from an associated ALTC funded project (Godfrey and King, 2011) in which a group of over 3000 commencing students from 2003 were surveyed as to their success in completing their engineering degree. This survey showed that those students with the lowest chance of completing, at only 20%, were domestic students who entered on the basis of VET studies or on mature age or special entry criteria. Thus, the six percent of the entering cohort to engineering bachelor degrees from VET diplomas and advanced diplomas are even further under-represented in graduating cohorts, because their completion rate is well under the rate of 40 - 75% across the whole cohort of 3000 commencing students from 2003. We conclude that in addressing the pathway from VET courses to bachelor degrees in engineering it is prudent to take account of information from previous studies on the obstacles encountered by students in taking such paths.

Two studies in 2011 provide important insight into the barriers students face in using VET courses as a pathway to bachelor degrees in engineering. The study by King, Dowling and Godfrey (2011) suggests that these arise from: the competency basis of VET diploma and advanced diplomas and inconsistencies in their assessment; variations in credit awarded by different higher education providers for the same VET qualification and the absence of mathematics as defined units of competency in engineering advanced diplomas. The study by Watson and McIntyre (2011) reports that obstacles for VET graduates in articulating to bachelor degrees in engineering are caused by: the inflexibility of vocational training that makes it difficult to ensure graduates are equipped with necessary foundation knowledge to undertake engineering degree programs; the lack of collaboration between the VET and higher education sector in identifying and addressing gaps in provision for such a pathway and the failure of both the VET and higher education institutions in providing academic support and meeting individual learning needs.

While the challenges in negotiating the VET to HE pathway in engineering exist, the insights provided by the studies above allowed this project to move forward. In particular we noted the following statement from Watson and McIntyre (2011):

Successful cross-sectoral partnerships are based on negotiated curriculum models designed to equip students in para-professional programs with adequate knowledge and skills for successful engagement in formal learning at the higher education level. Such models identify and eliminate knowledge and skills gaps for students on a VET-HE pathway, by specifying
exactly what components of the curriculum each institution will provide, and by providing additional learning support to students where necessary (p. 73).

The project proceeded on the basis of a need to increase the number of students articulating from VET diplomas and advanced diplomas to bachelor degrees in engineering and once there to provide them with a program that allows them to transition successfully. The project developed a pathway collaboratively using employees from both sectors, with a focus of enabling the pathway through ensuring adequate preparation of VET articulants in the mathematics they need for a bachelor degree in engineering.

Identifying the solution

This pathway investigated a way in which sufficient mathematics could be embedded into the VET AQF Level 5 awards to enable successful transition to first year Bachelor of Engineering courses (Figure 1). The project team was aware that a number of pathways already exist including those to non-Bachelor of Engineering awards that may in turn allow transfer to Bachelor of Engineering and courses that require a longer study period. The traditional VET pathway through the Advanced Diploma, no longer exists in some states (e.g. Tasmania), hence the gap from the Diploma to the Bachelor’s Degree is large for mathematics (Figure 1). Our solution incorporates contextualised learning to make the transition from competency/skills based learning to higher order thinking required in the HE sector smoother.

Figure 1. Pathways from VET engineering qualifications at AQF Levels 5 and 6 to HE programs. (Not all possible transfer paths are shown, and the bridging requirements and points of articulation vary between programs and for individual students) (modified from King, Dowling and Godfrey, 2011)
The project team initially identified the gaps in mathematics content between MEM50212 (Diploma of Engineering – Technical) and the typical mathematics entry requirements to Bachelor degrees in Engineering at The University of Tasmania. Once these knowledge gaps were identified, bridging units in mathematics available to VET to HE articulants were carefully examined to clearly pinpoint any remaining gaps in this pathway. New mathematical support resources were developed and housed as Open Education Resources (OER’s) on a project website http://www.utas.edu.au/mathematics-pathways/ to facilitate this transition with a specific focus on engineering applications and contexts. These resources aim to encourage articulants to pursue in their efforts to navigate the pathway from VET to HE by highlighting how mathematics plays a central role in solving modern engineering design problems in an applied setting.

The original goal of the mathematics pathway project was to ensure that those students who complete the pathway have mathematics knowledge equivalent to that they would have if they studied Mathematical Methods in the new suite of mathematics offerings provided by the Australian Curriculum, Assessment and Reporting Authority (ACARA). The rationale for this choice was that it is anticipated this subject will be the benchmark level of preparation in mathematics from secondary school for those choosing to study a Bachelor of Engineering degree at university: “the subject Mathematical Methods is designed for students whose future pathways may involve mathematics and statistics and their applications in a range of disciplines at the tertiary level.” (ACARA, 2014)

The pathway identified by the project team used existing VET units with mathematics content as the way by which students studying VET engineering diploma programs would cover mathematics content equivalent to that in Mathematics Methods from ACARA. These VET units are: MEM30012A (Apply mathematical techniques in a manufacturing engineering or related environment), MEM23004A (Apply mathematical techniques in a manufacturing engineering or related environment), MEM23007A (Apply calculus to engineering tasks).

The pathway provides access to these units through collaborative arrangements between VET and university providers. This collaboration arose because the VET units identified by the project team are not widely accessible in the VET sector. The collaborative arrangements involve VET students enrolling in units provided by tertiary institutions which when completed successfully give the students credit for study in the corresponding VET units. The units provided by the tertiary institutions are often used by students undertaking bridging study as preparation for study at university and are generic in nature (KMA002 and KMA003 at the University of Tasmania; Math1701 and Math1702 at Flinders University and MA1020 and MA1000 at James Cook University, Figure 2). Therefore significant effort was put toward developing online resources aligned to the mathematics in the units provided by the tertiary institutions, but with an applied engineering focus such as that VET students in engineering would experience.
Figure 2. Roadmap to the engineering mathematics pathway

To ensure that the pathway identified using these VET units appropriately matched the content in Mathematics Methods from ACARA, a detailed mapping of mathematics content between the ACARA Mathematics Methods subject, the identified units from the VET sector and the university bridging mathematics (University of Tasmania, Flinders University and James Cook University) units was undertaken. The mapping process revealed three mathematics topics which are covered in the VET units but are not covered in any of the bridging mathematics units at any of the participating universities. These are complex numbers, 1st and 2nd order differential equations and partial differentiation. These topics are also not included in the ACARA Mathematical Methods subject and are not considered a requirement of entry to the Bachelor of Engineering; however they need to be covered because students using this pathway ultimately receive credit for VET units.

The three topics that are not covered in the university bridging mathematics units are made available to students in the pathway using the online resources mentioned earlier. The mathematics is built on curriculum concept, supported by appropriate instruction and assessment, and designed to raise students' academic and vocational skills. The students are assessed using online testing to ensure competency in these topics before credit is granted for the corresponding VET units.

Summary

The mathematics pathway has been designed with an applied and integrated curriculum approach that connects academic and vocational learning to improve VET diploma of engineering students' transition and readiness for higher education study in engineering degree programs. It supports the engineering industry needs and fosters a broader engagement with, and valuing of, continuing engineering education.

The arrangements are flexible, so that students can complete these pathways as part of their engineering diploma as a VET student or as preparatory study at the diploma level at university. Students who are currently enrolled in one of the specified VET qualifications can
enroll in the mathematics foundation units at UTAS, complete the online component for the topics which are not covered in the foundation units, and if they successfully pass, will receive Recognition of Prior Learning (RPL) towards their Diploma of Engineering – Technical. Successful completion of the mathematics units will develop their mathematics skills to the level needed for entry (equivalent to Australian Curriculum Mathematical Methods) into the Bachelor of Engineering at UTAS.

The establishment of the pathway has been successful due to the collaboration between UTAS and TasTAFE, and valuable input and resources from the other University partners. To date, a Memorandum of Understanding (MOU) has been signed between UTAS and TasTAFE outlining the collaborative arrangements between the two institutions for the provision of the delivery of engineering courses and intent to work together to deliver the pathway for Engineering programs at all VET and HE campuses across Tasmania. This will include collaborative teaching where possible, working closely with TasTAFE staff to ensure teaching arrangements enable the smoothest possible transition for students between both institutions, and promotion of the pathway to schools and the broader community. The success of the pathway agreement between TasTAFE and UTAS will serve as a model for the other partner states (South Australia and Queensland) to complete an official pathway with their partner VET providers. These discussions will be facilitated by the project members in SA and QLD.

This pathway is part of a larger project addressing mathematics readiness of VET students not only in engineering but also education, health science and business. All of these pathways are currently under development (health science and business) or being trialed (engineering and education) with local VET and HE students. This project will run until mid-2015 upon which the results of the trial will be published.

Acknowledgements

The engineering project team would like to thank Kim Hainsworth from TasTAFE for her support for the partnership between TasTAFE and UTAS, Murray Orchard for assisting with the mathematics mapping and report and Richard Symonds for advice on current VET practice in educational programs. Support for this project has been provided by the Australian Government Office for Learning and Teaching. The views in this project do not necessarily reflect the views of the Australian Government Office for Learning and Teaching.

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Appendix E: Mapping Report

Mathematics Pathways Mapping Report

A Comparison of VET and HE

Mathematical Units

12 December 2013
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1.0 Project Background

Australia needs more qualified professionals in the areas of engineering, mathematics and science, education, health and other sciences. The national focus on widening participation in higher education (HE) includes strengthening pathways from vocational education and training (VET). VET students often lack the mathematics skills necessary to articulate successfully to their chosen degrees. Current approaches such as bridging and foundation mathematics programs, and university in-degree support, are fragmented and not tailored or sufficiently contextualised for VET articulants. Flexible approaches are needed that enable institutions to assess the numeracy skills of VET articulants and provide resources and supports to build their mathematical skills and confidence.

The Office of Learning and Teaching Project, ‘Developing Mathematical Pathways for VET students to articulate to related higher education courses’ will develop a series of mathematics pathways designed to assist Australian Qualifications Framework (AQF) compliance and improve readiness for HE study, providing credit where appropriate.

The objectives of this project are:

- To map the mathematical skills and knowledge required for students to articulate successfully from particular VET qualifications into particular, related HE courses, including AQF compliance in the areas of engineering, education, health sciences and business.
- To develop, trial and evaluate mathematics pathway resources and tailored bridging programs for VET graduates articulating from particular qualifications into particular, related HE courses.
- Make the pathways and learning resources available online, including as open education resources (OERs).
- To develop and support a community of practice amongst partner HE and VET institutions.

Expected outcomes will be:

- Build student confidence by using contextualised teaching of mathematics skills and knowledge;
- Increase VET articulation in HE; and
- VET articulants succeed in the HE environment.

Timeline of Project

<table>
<thead>
<tr>
<th>Month</th>
<th>Event</th>
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<tr>
<td>February 2013</td>
<td>Project start</td>
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<tr>
<td>December 2013</td>
<td>Pathway finalised</td>
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<tr>
<td>December 2013</td>
<td>Online component completed</td>
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<tr>
<td>February 2014</td>
<td>Engineering Trial to start with the university semester</td>
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<tr>
<td>October 2014</td>
<td>Engineering Trial to complete with the university semester</td>
</tr>
<tr>
<td>January 2015</td>
<td>Review of the pathway</td>
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<tr>
<td>July 2015</td>
<td>Project completion</td>
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</tbody>
</table>
2.0 Project Team

The project team is led by Professor Sue Kilpatrick from the University of Tasmania, Launceston, Tasmania. There are 10 project team members from three universities across Australia working with their VET counterparts (TasTAFE, TAFE SA and Tropical North Queensland TAFE) to develop pathways in the area of engineering.

University of Tasmania

- Professor Sue Kilpatrick, Pro-Vice Chancellor (Students)
- Dr Irene Penesis, Senior Lecturer, National Centre for Maritime Engineering and Hydrodynamics
- Ms Dayna Broun, Industry and Development Coordinator
- Associate Professor Giles Thomas, Acting Director National Centre for Maritime Engineering and Hydrodynamics
- Dr Bernardo A. León de la Barra, Lecturer, School of Engineering
- Dr Robin Barnes, Project Manager, Centre for University Pathways and Partnerships

Flinders University

- Professor John Roddick, Dean, School of Computer Science, Engineering and Mathematics
- Associate Professor Karl Sammut, Director, Centre for Maritime Engineering, Control and Imaging
- Mr Richard Symonds, Manager, Flinders:TAFE SA Partnerships; Academic and Student Services Partnerships
- Mr Paul Battersby, Project Officer

James Cook University

- Dr Shaun Belward, Head of Discipline of Mathematics and Statistics, School of Engineering and Physical Sciences
3.0 Proposal to Enable Better Transition of VET Diploma Graduates to University Bachelor of Engineering Courses

As part of a federal government Office of Teaching and Learning Grant, ‘Developing mathematics pathways for VET students to articulate to related higher education courses’, researchers from the University of Tasmania, Flinders University and James Cook University are investigating ways in which sufficient mathematics can be embedded in VET AQF Level 5 awards to enable successful transition to first year Bachelor of Engineering courses.

The project team is aware that a number of pathways already exist including:

1. Pathways to non-Bachelor of Engineering awards that may in turn allow transfer to the Bachelor of Engineering,
2. Pathways to Bachelor of Engineering courses that necessitate a longer study period due to the necessity of undertaking additional topics that may not currently be included within the existing Diploma of Engineering program.

There are several alternative possible pathways that could prove more attractive to the pool of potential TAFE/VET sector students and could reduce the overall time needed to satisfactorily complete the entire sequence of necessary units across the AQF5/BEng pathway. These include building pathways for:

1. Current TAFE/VET students in related Diploma of Engineering programs to Bachelor of Engineering programs,
2. Past TAFE/VET students in related Diploma of Engineering programs to Bachelor of Engineering programs, and
3. Current or Past TAFE/VET students in unrelated Diploma (not Engineering) programs to Bachelor of Engineering programs [this is not within the scope of this OLT project].

The strategies under consideration include:

1. Embedding mathematics into Diplomas,
2. Enabling pathways using university foundation units.

To facilitate the development of the above first two pathways, the proposal is to embed, as electives and where they do not already exist in the Diplomas, the units:

- MEM30012A (40 nominal hours)
- MEM23004A (80 nominal hours)
- MEM23007A (80 nominal hours)
- MEM23008A (120 nominal hours) (possibly)

To at least the following commonly available Diploma awards:
- ICT50210 Diploma of Telecommunications and Networking
- MEM50105 Diploma of Engineering - Advanced Trade
MEM50212  Diploma of Engineering - Technical  
MSA50108  Diploma of Manufacturing Technology  
RII50509  Diploma of Civil Construction  
UEE50111  Diploma of CSE  
UEE50411  Diploma of EE Engineering  
UEE50511  Diploma of Electronics and Communications Engineering  

This list is not exhaustive and please note that the traditional pathway of the Advanced Diploma is no longer available in Tasmania.

The topics within the above MEM units would be taught by a university in the form of university foundation units if the equivalent VET unit is not already being taught by a TAFE/RTO. This teaching would take students to the equivalent of the new National Curriculum subject Mathematical Methods (http://www.australiancurriculum.edu.au/SeniorSecondary/Mathematics/Mathematical-Methods/) which is the normal mathematics pre-requisite for a university Bachelor of Engineering degree.

Where students are unable to take the appropriate MEM units at their local VET institution, they may instead elect to complete existing bridging mathematics units KMA002 and KMA003 at the University of Tasmania or Math1701 and Math1702 at Flinders University, or MA1020 and MA1000 at James Cook University and will then be granted recognition of prior learning (RPL) for the MEM units identified.

In developing our strategies for delivering these pathways the following assumptions have been made:

1. That students have at least attained year 10 mathematics capability by the time they have completed Certificate IV,
2. That TAFE/VET will not teach more than they are paid to,
3. Students will need the equivalent of Mathematical Methods (please see link above) to satisfy the mathematics prerequisite for entry into Bachelor of Engineering programs, and
4. Universities will not charge fees to students for foundation units.

The proposed delivery methods may include a combination of one or more of the following:

1. Face to face,
2. Distance materials (books), and
3. Online

Alternative online options are also available which are run outside the partner universities

We are seeking collaboration with TAFE and VET sector institutions across Tasmania, South Australia and Queensland to establish a set of trial pathways so that we may evaluate the effectiveness of the proposed strategies.
The content of any external online course would require verification in order for it to meet the needs of this pathway with each university. Using existing online courses as a pathway is beyond the scope of this project.

4.0 Mathematics Mapping
The Mathematics Mapping has been completed (Table 1) in order to gain a solid understanding of the content offered in the VET units, University of Tasmania (UTAS), Flinders University (FU) and James Cook University (JCU) foundation units and compare these to the ACARA Mathematical Methods which currently stands as the entry requirement for Bachelor of Engineering programs.

The units which were examined were:

- ACARA – Mathematical Methods
- MEM23004A – Apply Technical Mathematics
- MEM23007A – Apply Calculus to Engineering Tasks
- MEM230012A – Apply Advanced Algebra and Numerical Methods to Engineering Tasks
- UTAS KMA002 – Applied Mathematics Foundation
- UTAS KMA003 – Mathematical Foundation
- FU MATH 1701 & 1702 – Mathematics Fundamentals A&B
- JCU MA1020 – Preparatory Mathematics
- JCU MA1000 – Mathematical Foundations

4.1 Gaps Identified
There are three mathematics topics that have been identified through the mapping process in which differences are evident between the VET and HE units.

- Complex numbers
- 1\textsuperscript{st} and 2\textsuperscript{nd} order differential equations
- Partial differentiation

These topics are covered in the MEM units but are not covered in any of the foundation level mathematics units at any of the participating universities.

These topics are also not included in the ACARA Mathematical Methods units and are not considered a requirement of entry to the Bachelor of Engineering but are covered in the 1\textsuperscript{st} year mathematics unit within the Bachelor of Engineering.

Clarification has been sought from Geoff Murray (Teacher of Engineering TasTAFE - Hobart) to establish the level of difficulty at which these topics are taught in the MEM units in order to satisfy the requirements for university entry and to receive RPL from TAFE. An ongoing collaboration with Geoff Murray has been established to review all materials on the
mathematics pathway website. His input will ensure that these materials are at the appropriate level for the articulating students and meet the requirements for RPL of the MEM units.

4.2 Mathematical Level
The content of the MEM units has been reviewed by the Project Team and it has been estimated that the MEM30012A unit is equivalent to a year 9 level. MEM30012A is also viewed as assumed knowledge for the University of Tasmania’s KMA units and for the other MEM units (MEM23004A, MEM23007A & MEM23008A) respectively.

Completing the series of MEM units in Table 1 or both of the university foundation units will be the equivalent of the ACARA Mathematical Methods for purposes of entry to a Bachelor of Engineering degree.
Table 1. Mathematics Courses Mapping. Courses include ACARA Senior Secondary Mathematical Methods, UTAS KMA002 and KMA003, TasTAFE MEM30012A, MEM23004A and MEM23004A, Flinders University MATH1701 & 2 and James Cook University MA1020 and MA1000.

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<th>Course Content</th>
<th>ACARA MM</th>
<th>KMA002</th>
<th>MEM30012A</th>
<th>MEM23004A</th>
<th>MEM23004A</th>
<th>MATH1701 &amp; 2</th>
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</tr>
<tr>
<td>Binomial Theorem &amp; Pascal’s triangle</td>
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<tr>
<td>Discrete random variables</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>distribution, variance, standard deviation</td>
<td></td>
<td></td>
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<tr>
<td>Binomial distribution</td>
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<td>Normal distribution</td>
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<td></td>
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<td></td>
<td></td>
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<tr>
<td>Proportions, confidence interval</td>
<td></td>
<td></td>
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<td></td>
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</tr>
</tbody>
</table>

**LEGEND**

- Green: included
- Purple: pre-requisite knowledge assumed
5.0 Pathway Progress

The proposed pathway has made significant progress based on a series of conversations between Kim Hainsworth, Dayna Broun and Irene Penesis. The following has been agreed:

- Students who are currently enrolled in one of the specified VET qualifications can enrol in the mathematics foundation units at the University of Tasmania (KMA002 & KMA003), complete the online component for the topics which are not covered in the foundation units and, if they successfully pass, will receive RPL towards their Diploma.
- A Memorandum of Understanding has been developed between UTAS and TasTAFE outlining the articulation pathway.
- The success of this pathway agreement will serve as a model for the other partner states (South Australia and Queensland) to complete an official pathway with their partner VET providers. These discussions will be facilitated by the project members in SA and QLD.
Appendix A: Course Comparison

A comparison of how each course is taught, including total contact hours and the type of assessment, has been completed (Table 2). The rigor of assessment methods and hence learning outcomes from the successful completion of courses with an examination component (i.e. university foundation units) are considered more thorough.

Table 2. Course Comparison Chart

<table>
<thead>
<tr>
<th>Course Code &amp; Title</th>
<th>Basic Information</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Source Institution</td>
</tr>
<tr>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>KMA002</td>
<td>UTAS</td>
</tr>
<tr>
<td>Applied Mathematics Foundation</td>
<td>1 hr tutorials</td>
</tr>
<tr>
<td>KMA003</td>
<td>UTAS</td>
</tr>
<tr>
<td>Mathematics Foundation</td>
<td>1 hr tutorials</td>
</tr>
<tr>
<td>MEM300012A</td>
<td>TasTAFE</td>
</tr>
<tr>
<td>Mathematics Fundamentals in a manufacturing engineering or related environment</td>
<td></td>
</tr>
<tr>
<td>MEM23004A</td>
<td>TasTAFE</td>
</tr>
<tr>
<td>Mathematics Fundamentals in a manufacturing environment</td>
<td></td>
</tr>
<tr>
<td>MEM23007A</td>
<td>TasTAFE</td>
</tr>
<tr>
<td>Mathematics Fundamentals in a manufacturing environment</td>
<td></td>
</tr>
<tr>
<td>MEM23008A</td>
<td>TasTAFE</td>
</tr>
<tr>
<td>Mathematics Fundamentals in a manufacturing environment</td>
<td></td>
</tr>
<tr>
<td>MATH 1701 &amp; 2</td>
<td>Flinders Uni</td>
</tr>
<tr>
<td>Mathematics Fundamentals A &amp; B</td>
<td>1 x 2 hr tutorial per week</td>
</tr>
<tr>
<td>MA1020</td>
<td>JCU</td>
</tr>
<tr>
<td>Preparatory Mathematics</td>
<td></td>
</tr>
<tr>
<td>MA1000</td>
<td>JCU</td>
</tr>
<tr>
<td>Mathematical Foundations</td>
<td>12 x 50 min workshops</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix B: ACARA Mathematical Methods

..\Mathematical Methods Nov 2012.pdf

Appendix C: VET unit outlines

1. ..\MEM23004A_R1 Apply technical mathematics.pdf
2. ..\MEM23007A_R1 Apply calculus to engineering tasks.pdf
3. ..\MEM30012A_R1 Apply mathematical techniques in a manufacturing engineering or related environment.pdf

Appendix D: HE unit outlines

a. University of Tasmania
1. KMA002 Applied Mathematics Foundation  
Semester 1, 2014  

Teaching staff:  
Dr Danijela Ivkovic  
Phone: 6226 2426  
Email: Danijela.Ivkovic@utas.edu.au  

Pre-requisites: There are no pre-requisites for this unit, but proficiency in grade 10 mathematics is recommended  

Teaching time: Semester 1, 2014  

Contact hours per week: 2 x 1hour lectures, 1x 1hour tutorial or a lab  

Unit Outline: Applied Mathematics Foundation Unit provides college level mathematics with non- calculus based content. The aim of this unit is to prepare students for the subjects which require basic algebra, data handling and statistics or discrete mathematics as part of their tertiary study.  

Topics:  
1. Set Theory: concepts and notations  
2. Linear Algebra: linear equations, linear graphs, systems of linear equations.  
3. Indices and Logarithms: index and logarithm laws, surds  
4. Sequences and series: arithmetic and geometric progressions  
5. Trigonometry: definitions, applications  
6. Probability: calculating probabilities, independent versus dependent events, conditional probability, Venn diagrams and probability tables  
7. Combinatorics: permutations, combinations  
8. Statistics: collecting data, presenting categorical and discrete data, correlation, distributions  

Assessment strategy: Fortnightly assignments: 40%; Exam: 60%.  

Learning outcomes: On successful completion of this unit, students should be able to read and communicate in relevant mathematical language and notation, use numerical calculations to solve real-world problems and graphically represent and interpret experimental data.

2. KMA003 Mathematics Foundation
Contact details

Teaching staff

Dr Danijela Ivkovic

Campus: Sandy Bay (Hobart)
Email: Danijela.Ivkovic@utas.edu.au
Phone: (03) 6226 2426
Room number: Room 436, Level 4, Maths & Physics Building

Unit coordinator

Karen Bradford

Campus: Sandy Bay (Hobart)
Email: Karen.Bradford@utas.edu.au
Phone: (03) 6226 2439
Fax: (03) 6226 2410
Room number: Room 417, Level 4, Maths & Physics Building
Consultation hours: Weekdays 9am – 5pm
Contents

Unit description 2
Learning outcomes 2
Prior knowledge &/or skills 2
Learning resources required 2
Details of teaching arrangements 4
Submission of assignments 4
Course Material 5
Assessment 6
Learning expectations and strategies 6
Academic referencing 6
Plagiarism 7
Occupational health and safety (OH&S) 7
Further information and assistance 7
Unit description

Mathematics, equipped with the powerful tools ‘logic’ and ‘reasoning’, is the key ingredient that enriches all areas of education. A sound knowledge in mathematics not only opens up numerous career options, but also helps to understand the world in which one operates. The unit aims to provide the necessary basic knowledge that is essential to undertake tertiary studies, which require pre-tertiary mathematics background. A brief look at basic concepts of number and algebra will lead us to the study of functions in general and the study of special functions such as trigonometric, exponential and logarithmic functions. The concept of the derivative of a function will be discussed, emphasising the importance of understanding the material conceptually and graphically. Graph sketching and optimization problems will demonstrate simple applications of the derivative. A brief look at integral calculus, with some applications in the direction of finding areas under curves, will bring this unit to a close.

Learning outcomes

On completion of this unit, you should have acquired knowledge of fundamental skills which are necessary to undertake an area of study which demands pre-tertiary mathematical skills. You should be able to:

• Use the notion of a function conceptually and graphically to investigate, interpret or manipulate results, as the need arises.
• Use conceptual understanding of differentiability of functions together with the associated technical skills to build mathematical models to optimization problems and arrive at solutions which are logically sound.
• Appreciate the applications of integral calculus which will be utilised in many areas of study at tertiary level.

Prior knowledge &/or skills

It will be assumed that students taking part in this course begin with some knowledge of the following ideas. Some of them may be discussed at the initial meeting.

• The number system and subsets of it – real/imaginary, rational/irrational, integers, positive/negative, the number line.
• Basic algebra – expansions (distributive law), factorising quadratics.
• Basic graphs – linear and quadratic, and variations (translations).
• Factors and zeros, and their relationship to graphs.
• The rectangular Cartesian coordinate system.
Learning resources required

Requisite texts
The textbook recommended for this unit is

E- (electronic) resources

MyLO

A range of useful resources can be accessed on the Mathematics Foundation Unit’s MyLO home page.

MyLO can be accessed from http://www.utas.edu.au/learning-teaching-online/. You will need your username and password issued by the university (which are the same as for the university email account) to log on the system.

A series of online quizzes will be made available on the Mathematics Foundation’s site on MyLO. While these quizzes are optional, we strongly recommend that you give them a try as they will help you develop your ability to apply mathematical concepts. The quizzes can be found in each of the Weekly Learning Modules.

To support your learning, you may wish to review the lecture videos and accompanying lecture notes recorded during previous iteration of the Mathematics Foundations Unit.

All lectures will be recorded and available for viewing through Lectopia.

You are encouraged to regularly access Mathematics Foundation Unit on MyLO to view your assignments marks and announcements, sign-up for tutorial groups and access online lectures, tutorials and other course material.

For information about accessing and using MyLO, see Student Resources & Support at http://www.utas.edu.au/learning-teaching-online/new-mylo/home. The University has a Service Desk dedicated to queries regarding MyLO and other university information technology services. The Service Desk can be contacted:

In person: at the Morris Miller Library (Sandy Bay campus) or the Launceston Campus Library.


By telephone: (03) 6226 1818

To access MyLO from your own computer you will need the appropriate software, and the hardware to run that software.
Blackboard Collaborate

Blackboard Collaborate is a Java based application which creates a virtual classroom with a whiteboard and a chat room. This virtual classroom will be used during lectures for the whiteboard. Students may choose to access this classroom to use the graphing calculator. This classroom can be accessed at http://tiny.cc/foundation_webroom.
Details of teaching arrangements

The unit runs over one semester with one 90 minute lecture (plus 10 minute break in the middle) and in one two hour tutorial per week.

We will also run Peer Assisted Study Sessions (PASS) where you can get support from students who successfully completed this unit in previous years.

Lectures
Lectures will be delivered via video conference from Hobart. Lecture notes can be downloaded from MyLO.

Tutorials
Tutorials are of two hours duration. Exercise sheets for tutorials are provided on MyLO. Students are encouraged to practice problems before attending tutorials

Submission of assignments

Assignments are due by Friday 4pm.

**HOBART:** Students can submit their assignments to the designated assignment boxes in the Maths and Physics foyer.
Hobart tutors: Jason Cosgrove Jason.Cosgrove@utas.edu.au

**LAUNCESTON:** Submission method to be organized by your tutor at the first tutorial.
Launceston tutor: Jeremy O’Reilly Jeremy.OReilly@utas.edu.au.

**BURNIE:** Submission method to be organized by your tutor at the first tutorial.
Burnie tutor: Murray Orchard Murray.Orchard@utas.edu.au.
## Course Material

<table>
<thead>
<tr>
<th>Topics</th>
<th>Reading from <em>Mathematical Methods</em> Lecture</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1 Introduction</strong></td>
<td>Course information</td>
</tr>
<tr>
<td>Description of course structure</td>
<td></td>
</tr>
<tr>
<td>Available resources (MyLO, Blackboard Collaborate)</td>
<td></td>
</tr>
<tr>
<td>Basic algebra and equations revision</td>
<td>2.1</td>
</tr>
<tr>
<td>Quadratics: factorising, completing the square, quadratic equation</td>
<td>4.2, 4.3</td>
</tr>
<tr>
<td><strong>2 Graphs and Polynomials</strong></td>
<td></td>
</tr>
<tr>
<td>Functions</td>
<td>1.2</td>
</tr>
<tr>
<td>Polynomials</td>
<td>4.1</td>
</tr>
<tr>
<td>Linear graphs</td>
<td>2.3</td>
</tr>
<tr>
<td>Quadratic graphs</td>
<td>4.2, 4.3</td>
</tr>
<tr>
<td>Cubic graphs</td>
<td>4.4</td>
</tr>
<tr>
<td>Polynomial division</td>
<td>4.1</td>
</tr>
<tr>
<td>Square root function</td>
<td>3.1</td>
</tr>
<tr>
<td>Function transformations</td>
<td>3.2, 3.3, 3.4</td>
</tr>
<tr>
<td>Hyperbola</td>
<td>3.1</td>
</tr>
<tr>
<td>Truncus</td>
<td>3.1</td>
</tr>
<tr>
<td>Absolute value function</td>
<td>1.7</td>
</tr>
<tr>
<td>Inverse Functions</td>
<td>1.7</td>
</tr>
<tr>
<td><strong>3 Logarithms and Exponentials</strong></td>
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</tr>
<tr>
<td>The index laws</td>
<td>5.3</td>
</tr>
<tr>
<td>Logarithm laws</td>
<td>5.4</td>
</tr>
<tr>
<td>Solving exponential and logarithmic equations</td>
<td>5.3, 5.4</td>
</tr>
<tr>
<td>Plotting Exponential and logarithmic graphs</td>
<td>5.1, 5.2</td>
</tr>
<tr>
<td>Exponential and logarithmic modelling</td>
<td>5.7, 5.8</td>
</tr>
<tr>
<td><strong>4 Trigonometry</strong></td>
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<tr>
<td>Unit circle</td>
<td>6.1</td>
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<tr>
<td>Symmetry and exact values</td>
<td>6.1</td>
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<tr>
<td>Trigonometric equations</td>
<td>6.1, 6.7</td>
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<tr>
<td>Trigonometric graphs</td>
<td>6.2, 6.3, 6.6</td>
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<tr>
<td>Trigonometric modelling</td>
<td>6.9</td>
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<tr>
<td>Trigonometric identities</td>
<td>6.8</td>
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<tr>
<td><strong>5 Differentiation</strong></td>
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<tr>
<td>Definition</td>
<td>9.1</td>
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<tr>
<td>Basic derivatives</td>
<td>9.2, 9.3, 9.5</td>
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<tr>
<td>Graphs sketching with critical points</td>
<td>9.8, 10.1, 10.4, 10.5</td>
</tr>
<tr>
<td>Rules of differentiation</td>
<td>9.6, 9.4, 9.7, 11.1, 11.4</td>
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<tr>
<td><strong>6 Integration</strong></td>
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<tr>
<td>Anti-differentiation</td>
<td>12.1, 12.2, 12.5</td>
</tr>
<tr>
<td>Integration by recognition</td>
<td>12.3, 12.4</td>
</tr>
<tr>
<td>Areas between two curves</td>
<td>12.6, 12.9</td>
</tr>
</tbody>
</table>
Assessment

The unit is graded on the basis of your performance in weekly assignments (40%) and the exam (60%). In order to pass the unit, students are required to achieve a pass mark in the exam.

Assignments

Weekly assignments will be worth 40% of the total mark. Assignments will be issued every second week and will be accessible through MyLO. The marked assignments will be returned at your designated tutorial. Late assignments will incur penalty.

In the odd weeks, students will be expected to complete quizzes on MyLO. Each quiz will allow you two attempts.

Assignments are worth 30% and quizzes 10% of the overall internal mark.

Exam

The exam is worth 60% of the final mark. Students are required to achieve a pass in the exam to pass the unit.

The exam will be invigilated and the examination office will notify you of the time and the venue closer to the date.

Learning expectations and strategies

Expectations

The University is committed to high standards of professional conduct in all activities, and holds its commitment and responsibilities to its students as being of paramount importance. Likewise, it holds expectations about the responsibilities students have as they pursue their studies within the special environment the University offers.

The University's Code of Conduct for Teaching and Learning states:

_Students are expected to participate actively and positively in the teaching/learning environment. They must attend classes when and as required, strive to maintain steady progress within the subject or unit framework, comply with workload expectations, and submit required work on time._

Learning strategies

To obtain the maximum benefit from the program it is essential that the student attend all the lectures and the tutorials. It is important to organise sufficient time on a daily basis to work through exercises and online quizzes. Completing these activities will help you to reinforce what you learnt during lectures. Any difficulties that arise as you attempt home-work problems and online quizzes must be discussed and clarified during tutorials.
Academic referencing

In your written work you will need to support your ideas by referring to scholarly literature, works of art and/or inventions. It is important that you understand how to correctly refer to the work of others and maintain academic integrity.

Failure to appropriately acknowledge the ideas of others constitutes academic dishonesty (plagiarism), a matter considered by the University of Tasmania as a serious offence.

For information on presentation of assignments, including referencing styles:


Please read the following statement on plagiarism. Should you require clarification please see your unit coordinator or lecturer.
Plagiarism

Plagiarism is a form of cheating. It is taking and using someone else’s thoughts, writings or inventions and representing them as your own; for example, using an author’s words without putting them in quotation marks and citing the source, using an author’s ideas without proper acknowledgment and citation, copying another student's work.

If you have any doubts about how to refer to the work of others in your assignments, please consult your lecturer or tutor for relevant referencing guidelines, and the academic integrity resources on the web at http://www.academicintegrity.utas.edu.au/

The intentional copying of someone else’s work as one’s own is a serious offence punishable by penalties that may range from a fine or deduction/cancellation of marks and, in the most serious of cases, to exclusion from a unit, a course or the University. Details of penalties that can be imposed are available in the Ordinance of Student Discipline – Part 3 Academic Misconduct, see http://www.utas.edu.au/universitycouncil/legislation/

The University and any persons authorised by the University may submit your assessable works to a plagiarism checking service, to obtain a report on possible instances of plagiarism. Assessable works may also be included in a reference database. It is a condition of this arrangement that the original author’s permission is required before a work within the database can be viewed.

For further information on this statement and general referencing guidelines, see http://www.utas.edu.au/plagiarism/ or follow the link under ‘Policy, Procedures and Feedback’ on the Current Students homepage.

Occupational health and safety (OH&S)

The University is committed to providing a safe and secure teaching and learning environment. In addition to specific requirements of this unit you should refer to the University's policy at: http://www.admin.utas.edu.au/hr/ohs/pol_proc/ohs.pdf

Any problems regarding access to the designated venues for lectures and tutorials should be directed to Karen Bradford.
Further information and assistance

If you are experiencing difficulties with your studies, have personal or life-planning issues, disability or illness which may affect your course of study, you are advised to raise these with your lecturer in the first instance.

There is a range of University-wide support services available to you including Teaching & Learning, Student Services and International Services. Please refer to the Current Students homepage at: http://www.utas.edu.au/students/ for information about these services.

Should you require assistance in accessing the Library visit their website for more information at http://www.utas.edu.au/library/
b. Flinders University

MATH1701 & 2 Mathematics Fundamentals A & B

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td><strong>Year</strong></td>
<td>2013</td>
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<tr>
<td><strong>Units</strong></td>
<td>4.5</td>
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<tr>
<td><strong>Class Contact</strong></td>
<td>4 50-minute lectures weekly</td>
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<tr>
<td></td>
<td>1 2-hour tutorial weekly</td>
</tr>
<tr>
<td><strong>Enrolment not permitted</strong></td>
<td>If 1 of MATH1122, MATH1202 has been successfully completed</td>
</tr>
<tr>
<td><strong>Assumed Knowledge</strong></td>
<td>A working knowledge of the arithmetic of positive and negative numbers, numerical fractions, natural powers and roots, basic properties of circles, rectangles and triangles, the idea of a variable, polynomials, idea of Cartesian coordinates and simple plots.</td>
</tr>
<tr>
<td><strong>Assessment</strong></td>
<td>Written Tutorial Questions, On-line Tests</td>
</tr>
</tbody>
</table>

**Topic Description**  
Mathematical Fundamentals A and B will comprise four modules each. All eight modules will be taught each semester, but students are allowed to combine any four modules to form a single semester of either Mathematical Fundamentals A or Mathematical fundamentals B, subject to the dependency of modules as set by the topic coordinator.  
Module 1. Equations of straight lines, linear inequalities, absolute value.  
Module 2. Second degree polynomials and their graphs, factoring, completing the square, solving quadratic equations.  
Module 3. Trigonometry of right angle triangles, solutions to simple trigonometric equations.  
Module 4. Unit Circle, angle addition formulas, double and half angle formulas, trigonometric identities, sine and cosine as function, graphs of trigonometric equations.  
Module 5. Functions, graphs, asymptotes, derivatives and integrals of polynomials, sine and cosine.  
Module 6. Negative and fractional exponents, logarithms, graphs of logs and exponential functions, derivatives and integrals of exponential functions.  
Module 7. Matrices, solutions to systems of equations, multiplication of matrices.  
Module 8. Counting, permutations, combinations, sets, binomial theorem, elementary probability.
c. James Cook University

James Cook University - Preparatory Mathematics - MA 1020

James Cook University - Mathematical Foundations - MA1000