Identifying and Supporting Quantitative Skills of 21st Century Workers

FINAL REPORT

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THE AUSTRALIAN ASSOCIATION OF MATHEMATICS TEACHERS INC.

AUSTRALIAN INDUSTRY GROUP

Identifying and Supporting Quantitative Skills of 21st Century Workers:
Final Report

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Publisher

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Reference Group

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Executive Summary and Key Messages

The Research Project

The Project was designed to examine the relationship between workplace mathematics and school practices and to identify:

- **the gaps between young peoples' quantitative skills in the senior years of schooling and the expectations of modern workplaces;**
- **how mathematical skills are conceptualised and used in workplace settings as opposed to the classroom; and**
- **the quantitative skills in use in workplaces, and how to best support the transfer and application of mathematical skills required in workplace contexts.**

Twelve teachers were selected to *'drill down'* and examine twelve volunteer workplaces. These were drawn from a cross-section of industries including engineering, drafting, manufacturing, retail, mining and defence. The teachers used semi-structured interviews, work shadowing, observations and qualitative analysis to provide insights into how workers use mathematical skills and concepts to perform practical tasks, focussing on:

- identifying the mathematical skills used in the workplaces and how these skills were acquired;
- seeking patterns and common characteristics in the workplace examples of the use of mathematics;
- identifying models that could be used to inform future practice around transfer of mathematical skills to the workplace; and
- investigating the skills and competencies that workers felt were needed for the job, and what they currently possessed.

Common Messages emerging from the Research

Overview

- The application of mathematics in the workplace is not straightforward and goes well beyond a command of 'core' mathematical content. Workers perform sophisticated functions which require them to be confident to use mathematical skills in problem-solving situations and to see the consequences of the mathematics related procedures.
- The sense is that workers need a blend of the following;
    - An understanding of the mathematical concepts, procedures and skills;
    - An understanding of the kinds of practical tasks they need to perform;
    - The strategic processes they should be able to use in applying mathematics

  There was evidence of a gap in the ability of young people to integrate these skills in the workplace. Current teaching approaches in schooling generally tend to emphasise these separately. Building these capacities through mathematics connects strongly with the general work on 'executive functions' that is emerging as important in preparing young people for work.
- Employers do have a view of the standard of mathematics that they are looking for in recruitment. Understanding this more exactly, and determining how the schooling sector could better communicate information about students' capabilities to industry requires further investigation.

The place and importance of mathematics

- Mathematics was considered extremely important in all of the companies involved.
- Changing work practices are generating new demands for mathematical skills, particularly in areas such as efficiency, innovation and Quality & Continuous Improvement.
- Managers and Supervisors also consider mathematics is very important in the *'maintaining operations'* and *'routine procedures'* of a company.

What mathematics is used in the workplaces

- The level of mathematics used by the workers observed, and required by employers, was generally from the *Essential* or *General* subjects of the new Senior Years Australian Curriculum.
- Although the skills observed can appear to be quite fundamental it is the *application* of mathematical skills to the workplace that is not straightforward. The mathematics used is never required in isolation, in contrast with common practices in schooling.
- The range of mathematical skills and understandings included:
    - integrated mathematics and technology skills
    - an ability to create a formula (often within a spreadsheet)
    - proportional reasoning, and calculating and understanding percentages correctly
    - modelling, including understanding thresholds and constraints
    - using extrapolation and extrapolating trends
    - recognising anomalies and errors
    - communicating mathematics to other users and interpreting the mathematics of other users
    - an ability to cope with the unexpected
    - fast and often multi-step calculations and estimations
    - Interpreting, and transforming between, different representations of numerical data (graphical and symbolic)
    - systematic and precise data-entry techniques and monitoring
    - concise and clear communication of judgements

How was mathematics is used in the workplaces

- Mathematics is applied in both routine and complex tasks that required the sophisticated use of fundamental mathematical skills as well as *'judgement'* or *'problem-solving'* which require more than facility with routine procedures.
- Workplace mathematics is carried out in ways that are different to how mathematics is taught and practised in schools..
- Mathematical demands may be present quite implicitly in the workplace tasks, often through tasks that are not obviously mathematical.
- There is a growing need in the workplace to communicate information effectively, based on mathematical data and inferences, and involving managers, colleagues and customers. Team-based working is becoming more common because of its importance in improving processes and this includes using mathematical reasoning and ideas by using appropriate language and representation.

The role of technology in the workplaces

- Many people in the workplace are engaged with technology, particularly in using spreadsheets and graphical outputs. There is an inter-dependency of mathematical skills and the use of technology in the workplace in ways that are not commonly reflected in current teaching practice.

- The general perception is that technology is transforming workplace practices and that the use of technology has changed the nature of the mathematical skills required – while not reducing the need for mathematics. Through technology change mathematics has become more embedded in the role of the modern worker.
- The extensive use of technology in the workplace has changed not only the way that work is done, but also the work itself – more sophisticated analyses can now be done using technology, and workers need to be more mathematically competent in order to assess the accuracy, understand and interpret the information produced by these analyses.

Implications for Teaching and Learning Mathematics

- Teachers should be provided with information about the wider uses of particular mathematical ideas in the workplace.
- There is a need to improve the connections for young people - in the workplace the mathematical skills are placed into a mathematical 'whole' (the process) but also embedded in a specific work context. Neither form of these types of connections are emphasised nearly enough in school mathematics.
- There should be an emphasis on building students' confidence and their ability to use mathematics in a range of familiar and unfamiliar contexts. It is now more important for teachers to consider how they teach rather than what they teach - what and how cannot be separated when working towards key areas such as critical thinking, communication, collaboration, and mathematical modelling.
- Given that the transfer of mathematical skill to the workplace is not straightforward, there is a need to promote the teaching of mathematical skills and understandings in a way that encourages transfer. The more contexts in which students are explicitly required and supported to transfer their mathematics, the more highly developed these skills will become.
- There is a need to identify and take opportunities to embed work-related technologies – particularly spreadsheets and computer generated graphics – in the mathematics curriculum and teaching in schools.

Recommendations and Actions

The following recommendations identify further work to be undertaken to support the development of the mathematical awareness, knowledge and attitudes in young people required by workers now and into the future. There are five key priority areas:

- Generating greater national awareness and understanding of how mathematical skills/processes/techniques are conceptualised and used in workplace settings.
- School based research and development of strategies for mathematics teaching to better reflect the real expectations of contemporary workplaces.
- Curriculum Development – the development of clear advice on how to support the development and transfer of mathematical skills to the workplace.
- A strategy for supporting change in schools.
- A strategy for supporting mathematical capability and numeracy in the workplace

Generating greater national awareness and understanding of how mathematical skills/processes/techniques are conceptualised and used in workplace settings

1. AAMT, Ai Group and OCS disseminate the findings from the *Identifying and Supporting Quantitative Skills of 21st Century Workers* project by preparing and distributing short summaries that inform and engage teachers, business, education authorities and relevant policy groups at the national, state and territory and local levels.

2. AAMT, Ai Group and OCS collaboratively plan and implement a series of Roundtables that involve mathematics teachers, AAMT state and territory Affiliates, mathematics educators and targeted Industry Skills Councils in strategic discussions on the scale and scope of the national challenges facing the application and transfer of mathematical skills in the workplace. The outcome of the Roundtables should be a synthesis of the discussions and identification of useful directions for uptake of the findings by both the Industry and education sectors.

School Based Research and Development of strategies for mathematics teaching to better reflect the real expectations of contemporary workplace

3. The AAMT, Ai Group and OCS identify examples from the Case Study Research that elaborate or exemplify mathematical principles and connections in the workplace. These examples will allow teachers to situate mathematics within contextualised practical workplace problems in their teaching and learning programs.

4. The AAMT seek support to undertake further collaborative research into the knowledge and pedagogical approaches required by teachers to better match the teaching of mathematics in school with the application of workplace mathematics in diverse teaching settings. This should include the development of a set of guidelines for the design of classroom activities that encourage and support the teaching and learning of mathematics within real world contexts - including the use workplace specific open-ended mathematical tasks for students.

5. The AAMT seek support to further consider and develop the connections between mathematical skills and executive functions as a key determinant of a student's success in transferring mathematics learnt at school to complex work and out of school situations. The research will provide improved understanding of how the relationship between thinking skills, executive functions, and mathematics concepts, procedures and skills can enhance the teaching and learning of mathematics and of mathematical use and competence in the workplace

Curriculum Development – the development of clear advice on how to support the development and transfer of mathematical skills to the workplace

6. The AAMT work with ACARA and Education Services Australia (ESA) to examine the relationship between the documented curriculum, classroom tasks for the learning of mathematics and the *Proficiency strands* and how they can be used to promote opportunities to build school-based interventions/approaches that better match classroom learning with workplace needs.

7. The AAMT work with ACARA, the Australian Council for Computers in Education and Industry to identify opportunities to embed work-related technologies – particularly spreadsheets and computer generated graphics – in the curriculum and teaching. This work will support and extend students' mathematical reasoning and sense making; provide access to mathematical content and problem-solving contexts; provide work relevant tools for computation, construction, and representation as students explore mathematical and interdisciplinary problems; and contribute to mathematical reflection, problem identification, and decision-making.

A strategy for supporting change in schools

8. The AAMT and Ai Group seek support to engage local partnerships between schools and businesses to identify and co-design practical demonstrations and 'teaching' activities that link the teaching of mathematics directly to workplace contexts. This work will be informed by the findings and materials from this project.

9. The AAMT and its state and territory Affiliates to develop and implement a focused professional development strategy, and support materials, for mathematics teachers to enhance their knowledge around the distinctions between the development and use of *mathematics* in the school as opposed to the world outside the classroom, specifically including the workplace.

A strategy for supporting mathematical capability and numeracy in the workplace

10. Given the project findings about the use of mathematics in the workplace, the Ai Group seek support to work with other organisations to further investigate the development of numeracy skills in the workplace as new workers enter the workforce.

Content

1. Rationale and Context for the Project

The reported national shortage of Science, Technology, Engineering and Mathematics (STEM) skills is generating action at National and State/Territory levels in fixing the science and mathematics supply line and build better bridges between educators and employers. This is based on research that shows that:

- Australia's participation in STEM skills at secondary school and university are unacceptably low;
- industry needs to become more engaged in the promotion of STEM skills at all levels of education and training; and
- there is an urgent need to introduce a number of strategies across the various sectors to lift participation in STEM-related activity.

There has been mounting concern about the state of mathematics in both secondary and tertiary education in Australia. In secondary education this concern has been expressed in relation to Australia's relatively poor performance in international comparisons as demonstrated in the Trends in Mathematics and Science Study (TIMSS) and the Programme for International Student Assessment (PISA).

The Australian Council for Educational Research (ACER), which administers the Australian component of PISA on behalf of the OECD, commented on the results:

> *"Some Australian teenagers may be trying to enter the workforce and forge a future for themselves with reading, mathematics and science literacy skills equivalent to a Year 7 or 8 education or worse."*[1]

The latest PISA results also present a bleak picture. The mathematics skills of 15 year olds have slipped back, as was also the case for reading. The results indicate that 16 countries achieved significantly higher results than Australia. Australia's mean mathematical literacy performance declined significantly between PISA 2003 and PISA 2012 by the equivalent of more than a half a year of schooling.[2] The results indicate that 42 per cent of the students failed to reach the national baseline proficiency level in mathematical literacy.[3]

There are additional concerns most recently expressed by the Australian Mathematical Sciences Institute in their *Discipline Profile of the Mathematical Sciences 2014* report.[4] This report highlights three critical concerns:

- About 40 per cent of Year 7 – 10 mathematics classes in Australian schools are taught without a qualified mathematics teacher;

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[1] MEDIA RELEASE, 7th December 2010, *PISA identifies challenges for Australian education.*

[2] MEDIA RELEASE, 3rd December 2013, *Latest PISA results 'cause for concern', says ACER*.

[3] ACER FACT SHEET, *Selected results from PISA 2012*, 3 December 2013

[4] Media Release, Dealing with Australia's mathematical deficit, AMSI, 12 June 2014.

- Year 12 enrolments in intermediate and advanced mathematics subjects have dropped34 per cent over the past 18 years; and
- Females are under-represented in mathematics in schools, higher education and the workforce.[5]

The Australian Council of Learned Academies has found that many of Australia's comparator countries achieve greater participation in Science, Technology, Engineering and Mathematics (STEM) subjects than Australia and noted the decline in student participation in senior mathematics.[6]

A report from Universities Australia highlighted a number of concerns in relation to secondary education including:

- in too many schools STEM is still mostly science and mathematics taught separately with little or no attention to technology and engineering; and
- students need to be made aware of the career opportunities afforded to STEM graduates at an earlier age rather than just years 11 and 12[7]

> *"The state of maths and science at Australian schools and universities has deteriorated to a dangerous level."[8](Vice-Chancellor Gavin Brown, University of Sydney)*

The basis of these concerns is the growing importance of STEM disciplines for the future economic and social well-being of Australia. International research indicates that 75% of the fastest growing occupations require STEM skills and knowledge.[9] Employment in STEM occupations is projected to grow at almost twice the pace of other occupations.[10] These skills are critical for Australia's national productivity and global competitiveness

The OECD *Over-Qualified or Under-Skilled: A review of Existing Literature* report published in 2011 notes that increasing demand for STEM graduates in the workforce is a result of:

- growing use and impact of information and communication technologies;
- rapid application of scientific advances in new products and processes;
- high rates of innovation required of business to stay competitive;
- declines in student enrolments in STEM particularly at secondary school; and
- shifts to more knowledge-intensive industries and services. [11]

> *"Investing in mathematics, engineering and science is the key to productivity growth and higher living standards for our community. An adequate supply of people highly skilled in mathematics and science is critical for our future success."[12]*

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[5] Ibid.

[6] STEM: Country Comparisons, Final Report, Australian Council of Learned Academies, May 2013.

[7] Universities Australia, *STEM and non-STEM First Year Students*, January 2012.

[8] http://www.theaustralian.com.au/news/nation/mathematics-students-in-serious-decline, March 10, 2010.

[9] Becker, K. and Park, K.; Effects of integrative approaches among STEM subjects on students' learning, Journal of STEM Education 12, July – September 2011.

[10] Elizabeth Craig et al., No Shortage of Talent: How the global market is producing the STEM Skills needed for growth, September 2011, Accenture Institute for High Performance.

[11] OECD; *Over-Qualified or Under-Skilled: A review of Existing Literature*, OECD Social, Employment and Migration Working Papers, No 121, Paris, 2011.

Australia's performance in mathematics, and more broadly STEM-related disciplines, provides an important context for this project. This project considers the related issue of the transfer of mathematical capability in school to the workforce. The Office of the Chief Scientist highlighted this specific problem in their research:

> *"The review commented that teaching needs to be high quality and inspirational while content is generally seen as …. irrelevant to life after school. The teaching is seen as boring because so much is seen as knowledge transmission of correct answers with neither time nor room for creativity, reflection or offering opinions*."[13]

With this issue at the forefront this research project developed a number of specific objectives, including a detailed identification of common quantitative skills (mathematical) that can form the mathematics component of the STEM skills expectations for non-graduate workers. This could inform strategies to implement 'school-industry" STEM skills initiatives that will help students to deeply explore the STEM disciplines through teaching and learning experiences that connect learning to relevant STEM Industries and career opportunities.

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[12] Evans, C, Maths for the Future – Keep Australia Competitive Forum, Speech to the Australian Mathematical Sciences Institute, Canberra, February 2012.

[13] *Studying STEM: What are the barriers?*, The Institution of Engineering and Technology United Kingdom, 2008 cited in Mathematics, Engineering & Science in the National Interest, Office of the Chief Scientist, May 2012, page 20.

2. Research Context and Case Study Methodology

a. Objectives of the Research

The Project was designed to look at the requirements for mathematical skills and understanding in the modern workplace and to develop a clearer picture of the matches and mismatches between current mathematics (curriculum, teaching methods and resources) and the quantitative skills required. This included:

- exploring what mathematical skills are used in the workplace and how the skills were acquired;
- Identifying any common characteristics found in the examples and models that could be used to inform future practice and directions related to the development, enhancement and transference of mathematical skills to the workplace;
- Identifying and analysing the gaps between young peoples' mathematical skills in the senior years of schooling and the expectations of modern workplaces; and
- Identifying and documenting the skills in use in workplaces, and how to best support the transfer and application of mathematical skills required in workplace contexts.

The Project aimed to promote further consideration and an informed emphasis by mathematics teachers on mathematics in and for the workplace.

In addition to this Final Report a supporting document has been developed as part of the Project - The *Quantitative Skills Map* – has been drawn from the Case Study research and identifies some common quantitative skills that are expected for non-graduate workers across a range of workplaces.

b. Case Studies - Overview

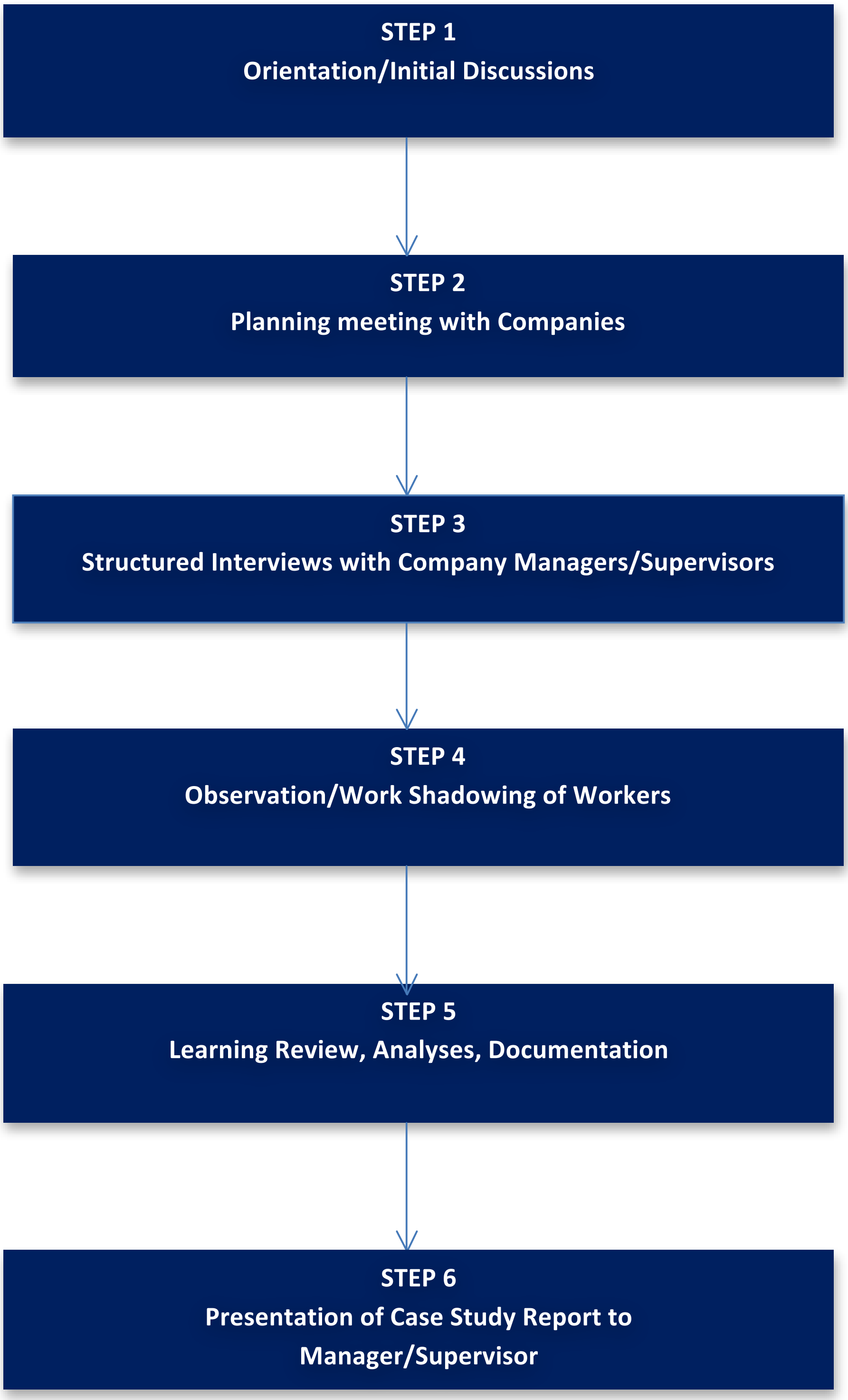
The Project has utilised a case study approach to explore what can be learned by examining specific worksites in more detail. Ten companies were selected to participate in a series of case studies across Australia, with teachers undertaking the research in twelve different worksites. The sample of companies examined in the research study cannot be regarded as fully representative of all industry sectors although they represented a range of different profiles in terms of size, employees and production outcomes.

The case study approach included arrangements for work shadowing and interviews by selected mathematics teachers with workers, supervisors and managers to explore a range of issues including the mathematical skills used at the worksite, workers' recollections of, and attitudes towards the experience of mathematics at school, transfer of mathematical skills acquired at school and workers' engagement with work related tasks involving mathematics.

Twelve teachers were selected to provide qualitative analysis and insights into how workers use mathematical skills and ideas to do practical tasks. The study into specific workplace practices has enabled the Project to examine the skills used and how they have been adapted to particular workplaces.

Interviews and work shadowing in the case study sites were guided by themes derived from Australian and international research into workplace numeracy and literacy.

The Case – Study process involved a number of stages as outlined below.



At the completion of the observation process each teacher prepared a *Case Study Report* – using the following headings as a guide. This structure was based on the broad findings derived from the NCVER Report *Thinking beyond Numbers - Learning numeracy for the future workplace*

[14];

- Background - The workplace; occupation profile;
- The mathematical skills that were used and specific example of when they were needed and how they were used;
- The context in which the mathematical skills were used – i.e. OHS, Quality, Routine, Innovation, etc.;
- How workers learned mathematics related tasks - the most effective ways that workers learn;
- Were workers conscious of using mathematical skills - beyond operational use of mathematical procedures;
- Relationship between workplace mathematical skills and school mathematics;
- Transfer – work and school.

Teachers provided the Report to the manager/supervisor of the company for their feedback and endorsement.

The *Case Study Reports* have been used to identify key themes and messages and examine the implications of mathematics use in the workplace for mathematics education.

c. The selection of Workplaces and Teachers

The Selection of participating mathematics teacher-researchers

The Project was announced at the AAMT Conference in July with the opportunity for teachers to be involved. Subsequently the Project was promoted through the association's networks of members and others.

The Project team designed and conducted an Expression of Interest process in September 2013. Twelve Teachers were selected to participate in the project. The selected teachers were employed (either full-time or part-time), teaching some mathematics in a school, had previous experience in school to work programs and through their expressions of interest demonstrated evidence of:

- good communication skills;
- the desire and ability to work with others;
- the ability to analyse and present their observations and findings; and
- the capacity to meet deadlines and other challenges.

The teachers selected were well placed to identify the particular mathematical skills which are needed for particular occupations and examine the relevance of current programs and services to the actual mathematical requirements of the job. Each teacher was recommended for involvement by their principal. Subsequently, AAMT signed agreements with both the individual teacher and the school (through the Principal) in which the expectations for the project were specified.

[14] NCVER (National Centre for Vocational Education Research) 2007: Thinking beyond numbers Learning numeracy for the future workplace: Beth Marr RMIT University Jan Hagston Swinburne University of Technology—TAFE

Selection of participating workplaces

Ai Group announced the project and opportunity for businesses/ workplaces to be involved through its education and training networks. It also designed and conducted an Expression of Interest process to select at least 12 businesses/workplaces to participate in the project.

The selection of Business was based on their willingness to:

- assist better understanding of the mathematical skills required by workers, and how these can be developed;
- learn more about mathematics educational processes; and
- participate in an ongoing partnership and dialogue with the school sector in terms of industry-school links.

A profile of the companies involved is outlined in the table below.

Company	State	Company Profile
Power and Automation Engineering Company	NSW	The NSW site of the company employs about 500 people and carries out assembly work and product testing, in addition to accommodating sales, product and project managers, design engineers and corporate functions. The Company's operations are made up of specific business units focused on particular industries and product categories. Its products and solutions serve a number of industries including mining, oil and gas, manufacturing, utilities, paper, transport, marine, consumer, automotive and building industries. The participating teacher had the opportunity to observe workers in the areas of Finance/Business Control, Information Systems, Energy Futures and Sustainability.
Engineering Company	SA	A diversified company providing solutions to Australia's infrastructure projects and manufacturing in Australia. The companies key capabilities includes: • Water and water re-use solutions • General Engineering • Manufacturing Their principal markets include: *Power; Defence; Water; Mining and Quarrying; Outsourced Manufacture for OEM's* The participating teacher had the opportunity to observe processes undertaken at Adelaide's manufacturing site in Adelaide, featuring: • High-end machining capability; • Specialised fitting and assembly; • Wide ranging fabrication skills from heavy plate work to pressure vessel manufacture; • Manufacture of complex products; and • Specialised vehicle equipment manufacture
Drafting Service Provider	SA	An independent company specialising in the provision of drafting services. As an 'end to end' service provider the Company offers a full range of services to its clients that can be accessed in a variety of ways to suit their unique needs. The company's clients range from major EPCM's looking to supplement their existing workforce, through to smaller engineers and fabricators looking to boost their internal CAD resources. The Company also supplies technical recruitment, supplying expert off-site drafters for the short, medium or long term

		With a diverse range of CAD software platforms, the Company offers a full design service across most disciplines, as well as CAD Drafting in all its forms - from basic 2D layouts through to more complex 3D modelling and design. The participating teacher had the opportunity to observe workers providing a range of services including design and drafting for the mechanical, structural, piping, civil and electrical disciplines.
Heavy Vehicle Dealership	NT	The Company is one of the largest Caterpillar dealer networks in the world; with over 23 branches, 26 sub-branches and nearly 5,000 employees. They have distribution rights for the sale and rental of Caterpillar heavy equipment, parts and service support in Queensland, Northern Territory, Papua New Guinea, New Caledonia and the Solomon Islands. The Company sells, services, rents and supports the complete range of Caterpillar machinery used in the mining, construction, forestry, agricultural, materials handling and government sectors. The Company provides end-to-end equipment management with service, integrated solutions, after-sales support, fast and efficient parts fulfillment, training and assessment services, and remanufacturing capabilities. Other associated products include Caterpillar underground mining equipment and hard chroming services. The participating teacher had the opportunity to observe operations in a variety of fields including workers as shop or field service technicians within the dealership network. This included the training of apprentices using the latest Caterpillar technology and resources in state-of-the-art facilities.
Manufacturing Company	QLD	The Company manufactures round line welded construction hydraulic cylinders in one of Australia's most modern and best equipped cylinder manufacturing facility. The product range incorporates Australia's widest range of high quality cast steel mountings, supported by client access to 3D modelling. It also provides a range of services to fulfil hydraulic systems requirements. The company employs a staff of 40 consisting of designers, sales people, programmers, machinists, assemblers and receptionists. It is one of eight major cylinder companies. The participating teacher had the opportunity to observe the in-house design engineering team who - can custom design mounting options to meet special project requirements during the project design phase or as required for each cylinder; provide assistance with engineering calculation to ensure the cylinders meet the required specification of application; use accurate 3D models for a large range of cylinders, modified to achieve the required stroke, open and close measurements for specific projects.
Energy Management	ACT	The company is a specialist in energy management that offers solutions to help customers make energy safer, more reliable, efficient and productive. They have an extensive collection of electrical products for the distribution, protection, control and management of electrical systems in low voltage environments. Their products and solutions are designed and built to help individuals and organisations make the most of their energy. The company services offer the benefits of true life cycle support for your electrical distribution and automation systems. Teachers had the opportunity to observe workers in; [Sales and Marketing – to help customers make the most of their energy by delivering solutions suited to their needs [Operations - that aim to improve product performance and customer satisfaction and develop solutions combining flexibility, security and productivity.

		• Technical - technical teams in the field in direct contact with customers that apply technical training and know-how in e areas like green technologies or advanced software. • Business and Support Strategy - cross-functional positions that support core business
Mining Company	NSW	The company is a copper/gold producing mine that operates underground block cave mines on its mining leases. Teachers had the opportunity to observe workers in • The Grinding process – where a Process Technician monitors all operations using computer-aided devices and systems for any faults/breakdowns as well as maximise productivity. • The Floatation Process – where Process technicians and Engineers work together to maximise amount of copper/gold extracted. Watch computer screens for data/statistics and any faults/breakdowns
Rural Supply Company	WA	The company deals in farm supplies, both domestic and mechanical, selling everything from washing powder, to safety gear, to tools, to irrigation and fencing requirements with the main turnover being agricultural chemicals The company employs seven people who deal directly with customers and their ability deliver a high level of customer service is highly regarded
Property and Infrastructure Company	NSW	The company is a fully integrated, international property and infrastructure group, responsible for a $6bn urban transformation of the western edge of Sydney's central business district - home to around 1,200 residents, 23,000 office workers and more than 2.9 hectares of public space. The transformation involves collaborating with a team of award-winning architects, designers, engineers and sustainability experts. The participating teacher had the opportunity to observe crew to perform the Formwork Trade for the three International Towers. This will include Leading Hands, Carpenters, Formwork to focus engineered solutions and systems which could include; • Self-climbing jump form system • Modular formwork panel systems • Self-climbing perimeter protective screens • Custom table form systems with integrated self-climbing hoists.
Defence Company	SA NSW	The company is the largest defence contractor in Australia and operates from sites across the country in support of defence and security customers. It provides products and services to the Australian Defence Force (including: Fast Jet support, Military Flight Training, Autonomous Systems, Guided Weapons (naval air defence) and Communications, Command & Support. BAE Systems Australia operates four business units. Aerospace, Land & Integrated Systems (L&IS), Maritime, and Defence Logistics The company employs approximately 6,000 people Australia-wide with - 700 – 800 at SA site and approximately 300 in the NSW site. The teachers were to be utilised to observe key skills in engineering and systems integration across three sites covering possible areas of work that include: *Airworthiness; Design; Electrical; Mechanical; Optics; Software; Structural; Systems* and work roles that include – *Drillers; Electricians; Fitters; Manufacturing Management; Planning; Production; Steelworkers; Welders*

3. Themes Emerging from the Case Studies

a. The Importance of Mathematics in the Modern Workplace

From the managers' and supervisors' point of view, changes in workplace practices are making the use of mathematical skills more important. Changes in dealing with innovation, informing improvement and remaining competitive have resulted in increasing numbers of people involved in mathematics-related work. The mathematical application and understanding is becoming a required skill for all people in the workplace, even in entry-level positions.

> **In terms of Technology & Innovation, the Company needs to cope with the changing face of Business, Industry & the Economy. Understanding Business Principles and being able to "analyse the numbers" (& data) are important to ascertain where the growth will be coming from in the future. For example - we used to do a lot of work in Structural Steel but now Mining is more profitable even though it is smaller. This is where analysis and the breakdown of figures is important. Specializing is out and more "General" drawing will be in. We have to be agile enough to move to where the growth is. To do that, you have to understand the data that business is involved in – *Managing Director Drafting Company SA***

Mathematics was considered important in:

- *A company's drive for efficiency* - although company practices varied, a common feature was the expectation that all employees, regardless of level, were involved in the process of increasing productivity or producing efficiency gains, and therefore employees needed relevant mathematical understanding.

- *Innovation* **-** fast-changing company practices appear to be generating a new demand for mathematical skills.

- *Quality, continuous improvement* **–** mathematical skills are required for examining higher levels of quality, smaller margins of error and tolerances, reduction of wastage and quality procedures.

Mathematics is also considered very important in the *'maintaining operations'* and *'routine procedures'* of a company. In these cases workers need to be able to make sense of the mathematics they are using if they are to avoid making mistakes in the workplace.

Managers and supervisors were very aware of the potential value and importance of mathematics skills for their workforce, as outlined below.

You use Mathematics everywhere - you need to know what you're looking for with Mathematics - don't trust machines. Math drives design - Area, 3D, Volume are all done by "hitting the button" but workers need to have an understanding of the Mathematics involved in design drawing – *Design Drafter Drafting Company SA*

Having a knowledge of Mathematics is "Paramount" in the workplace – it is fundamental as part of the "functionality of creating things" such as structures. Having basic maths - knowledge of times tables, being able to add, divide, subtract and multiply are all essential but it is also important to have logical thinking & being able to interpret Engineer's instructions – *Quality Control Coordinator Drafting Company SA*

The application and accuracy of mathematical skills is paramount for the safety and cost to the Company and the companies they supply and support. For example, when "dogging* the worker must be highly trained and competent when lifting, so that loads do not become unbalanced and supporting cables or chains do not break. This could result in the damage to equipment and resources and, more importantly, jeopardise the safety of workers. In regards to the assembly side of components, if preloads and positioning of parts aren't correctly calculated then this could cause safety risks for the employees, damage to machinery in excess of $50 000 and production loss for the customer - either through the specific piece of machinery not being able to be used or a broken down vehicle blocking an incline on a mining site – *Training Coordinator NT*

When asked about the levels of importance attributed to various mathematical concepts, the owner cited three main areas that he regarded as being of very high importance. These were calculation and estimation (both mental and with some form of technology), the recognition of patterns and anomalies, and the ability to communicate mathematically related ideas - *Director Manufacturing Company QLD*

Mathematics is extremely important in this workplace as the industry revolves around precise calculations and measurements. All elements of the manufacturing process in this business from design and production to sales rely on numbers and formulas. They need to know and understand mathematics. An understanding of mathematics is critical as it not only helps employees produce a product it also allows employees to spot discrepancies and anomalies. It is also important in relation to safety which is paramount in this industry. The mathematics dealt with in most instances is not difficult but employees need to be accurate and understand what they are doing and why they are doing it – *Technology Manager Engineering Co. NSW*

Use of Mathematics is integral to the operations of the Company. Use of essential skills ranges from the use of every day measurement, calculation, costing, location, and reading meters to the use of sophisticated mathematical processes used in making NEBORS ratings, regression analysis, risk management, and programming - mathematics is used to organise communication workflow, to do energy audits, to give data to colleagues for them to work on. Within this division (BMS) the majority of the work is based on fault finding. This process has very strong links to mathematical ways of thinking – or problem solving strategies, logical processes and communication of these to the customers concerned - the importance of employees being able to problem solve in a logical way, being able to complete those processes in a time constraint situation (linked this concept to students being used to testing in the school environment), and then communicate the problem and proposed solution in an articulate manner to superiors and the customer in the workplace. The Manager indicated that mathematical ways of thinking were continually being used by technicians in his area, sometimes without them realising that they were doing so – *Service Delivery Manager ACT*

b. The Mathematical content required in the workplace

Mathematical usage in the workplace generally fell into two categories:

- the high-end use of mathematics by those with qualifications that included a substantial mathematical element in specialised or professional roles; and
- the use of mathematics by those not requiring a numerate degree or mathematical specialism who usually operate in technical or trade roles.

The research predominantly focussed on this latter group. The level of mathematics generally used by of workers in these roles, and required by employers, can be described as the use of *'core'* or *'fundamental'* mathematical techniques and processes.

Our Technicians all use basic calculations, both with and without calculators, including working with percentages (drives air conditioning, VAV (Variable Air Volume), Damper, bypass, efficiency), measurement, proportion, data representation and analysis, and pattern recognition. Mental calculations include very good estimation skills, particularly knowing what a 'good' (or correct) answer should look like – *Service Delivery Manager ACT*
The mathematical concepts that are regarded by the company as having a degree of importance are the calculation and interpretation of percentages, measurement, display and interpretation of data, the use and interpretation of graphs, charts and tables, the use of computers and technology and the use of mathematical ideas and concepts to model or analyse workplace situations. Most of these skills are for the routine execution of the workers job – *Workshop Manager NSW*
A variety of mathematical skills is used within this workplace. All employees need basic mathematical skills and specific mathematical skills in relation to their particular job. Mathematical skills used: number skills (addition, subtraction, division, multiplication), data processing and analysis, measurement, formulas, interpreting plans, diagrams and scale drawing, compiling and reading graphs, charts and tables. Trigonometry plays a significant role in this industry. Employees also need calculator skills. Some employees also use problem solving skills at various stages – *Draftsperson QLD*
Workers need to determine the energy efficiency of a building, including how 'clean" the energy is. It is based on the area of a building, tenancy numbers, power consumption and they need to quantify energy use, and to benchmark changes over time. They therefore need to be able to communicate numerical/ electrical/controller data to clients - *Solutions Manager ACT*
The main areas of Mathematics that are used on the work floor are: Basic arithmetic – addition and subtraction; Angles Unit conversion, Ratio Reading gauges and tables of values; Interpreting graphs and statistical data application of formulas – *Training Coordinator NSW*
The following are used on a daily basis by workers - Mental Calculations / Estimations; Measurement; Display & Interpretation of data; Graphs, Charts and Tables; Scale drawings, plans and diagrams; Recognition of Patterns and Anomalies with Measurement & data and Communication of Mathematical ideas – *Design Drafter SA*
The Manager identified the following as "Important": Calculation; Calculation & interpretation of Percentage; Use of Ratio and Proportion and Use of Computers & Technology – *General Manager SA*
Workers have to use Basic Numeracy, Software related skills (e.g. spread sheets), estimation skills, formula development, measurement – *Workshop Manager NSW*

Although the mathematical content required differs from workplace to workplace, the level of the mathematics required is almost wholly covered within the *Essential* or *General* subjects in the new Australian Curriculum[15]. The skills observed can appear to be quite fundamental - such as how to calculate and estimate (often quickly and mentally), and having a feel for numbers, percentages and proportions – but in many cases it is the *application* of mathematical skills in the workplace that is not straightforward. The mathematics used is never required in isolation. They are always operationalised with real data/information and with an appreciation of what the data/information means. In many of the examples what would be regarded as core mathematical concepts have to be used analytically and in sophisticated ways in the workplace.

Supervisors and managers interviewed, and workers observed at each of the case study sites, were presented with a list of mathematical skills - derived from *Australian and International workplace Numeracy Research* such as *OECD PIAAC Research Numeracy: A Conceptual Framework* – and asked to indicate whether and how they were used and to provide examples of the types of tasks in which the skills were used. These mathematical skills included -

- Measurement.
- Estimation.
- Number skills—undertaking calculations.
- Use of formulae.
- Interpreting plans, diagrams and scale drawings.
- Graphs, charts and tables.
- Evaluation, critique and modelling using mathematical concepts.

The following table summarises the general mathematical skills frequently observed in use in the case study workplaces. The lists are not intended to be exhaustive but rather to demonstrate the range and variability of mathematical skills actually deployed across the case study companies.

[15] Note that these subjects reflect content covered in various senior mathematics subjects in the jurisdictions before the advent of the national curriculum. In other words, this mathematics has long been a part of the mathematics curriculum in the senior years of schooling.

Mathematical Skill	Uses in the Workplace
Measurement	Varieties of measurements are required to be performed daily by workers. They must be appropriate to workplace needs and up to workplace standards and accuracy requirements. Workplace activities related to measurement generally include: ⟦ making initial estimates of measurement and performing the measurement correctly using appropriate instruments; ⟦ interpreting concepts and units of measure using and describing using suitable language and symbols; ⟦ choosing appropriate formulae and using to calculate quantities of common shapes; ⟦ performing conversion between metric units; and ⟦ checking reasonableness of results and interpreting in terms of original purpose.
Estimation	Workers are often required to estimate approximate answers when exact calculations are not required. They need to know when to make a choice between calculation and estimation - depending on a particular process Workers are required to identify estimation requirements and select appropriate estimation methods to meet work requirements. Estimations can take the place of a precise calculation where precision is not required, or can be used to mentally check whether an error has been made.
Number skills—undertaking calculations	Calculation is used by most workers who are required to apply basic mathematical concepts to calculate workplace information. Calculations may be performed manually or using a calculator or computer. Even when using technology such as calculators and computers, workers often have to think through a problem first to work out the right calculations to perform according to the situation. They also need to know how to use the technology. Calculations involving *multiplication*, *addition* and *subtraction* are performed on whole numbers (for product quantities) and *decimals* (associated with measurements and money) on a daily basis. *Percentages* are calculated by workers and apply to many functions in the workplace. Workers need to understand what they mean and how to work with them. Workplaces use percentages to communicate workplace information such as productivity and performance data. *Ratio and Proportion* - Understanding and working with quantities and proportions.

Use of formulae	A diverse range of simple mathematical formulae are used effectively by workers in the course of their jobs. They often use formulas such as when calculating areas, volumes, dimensions and flow rates. They also need to select and use appropriate formulae to calculate the measurement properties of common shapes. They need the ability to create formulae through an understanding of relationships between variables.
Interpreting plans, diagrams and scale drawings	Many workers use drawings, plans and diagrams in their day-to-day jobs and are involved in reading and interpreting some aspects of plans and diagrams - particularly with an array of symbols and measurements. Interpret scales in diagrams Workers solve problems using plans, drawings and diagrams Workers are required to create and investigate shapes and their representation
Graphs, charts and tables	Mathematical use was noticeable with respect to graphs, charts and tables. Workers used tables of product sizes, specifications, costs etc. on a daily basis. The ability to interpret mathematical data is essential to the workplace particularly in problem solving and quality improvement. Ability to read, interpret and transform data from charts and spreadsheets. Interpret Statistics data to monitor quality of products. Recognise trends in data.
Evaluation, critique and modelling using mathematical concepts	Many job tasks involve problem solving and decision-making using mathematical skills. Workers use mathematical problem-solving techniques to investigate and solve workplace problems and undertake sophisticated tasks. This includes the ability to: - reflect on the reasonableness and accuracy of their results and possible alternative methods and solutions; - model mathematical information; and - communicate data and mathematical information.

c. The use of mathematics in the workplace Context

The general observation across the case study sites was that workplace mathematics is carried out in ways that are different to how mathematics is taught in schools. It often involves the use of technology and is more often than not used in collaboration with others. People in the workplace need to choose the appropriate mathematics, sometimes under pressure. They then need to apply it, and make informed judgements using the results. The mathematics often involves procedures, graphs and other tools that are often specific to a particular workplace – and very different to those used in school mathematics.

For example, in the company supplying agricultural chemicals a frequently-cited need was an understanding of basic proportionality, which is required for the preparation of chemical solutions to specified concentrations. This clearly involves a grasp of basic and generalised mathematics skills; but here too, it is essential that people understand what they are doing.: that is, what calculations mean in the context of the work. There is no guarantee that someone who has an understanding of proportions could relate this to an understanding in working with concentration and dilution of solutions –

The skills required by workers are not simply those associated with 'core' level mathematical techniques but particular mathematical skills or practices which are determined by the circumstances and particular purposes of the work task. Mathematical skills are used in a very particular or contextualised manner in each workplace.

Mathematics in the workplace is quite different from mathematics in school. It is more concrete and more intuitive, yet at the same time more exacting and more unpredictable. It is rich in data and inextricably linked with technology. Technicians and other workers are routinely expected to carry out multistep applications of simple mathematics-- especially three-dimensional geometry, triangle trigonometry, and elementary data analysis – ***Managing Director SA***

The mathematical content also looks different in the workplace from what is presented in schools. For example rather than following mathematical rules and conventions to the letter - approximation and estimation is used in ways that is suitable for the work task are - however, this use of approximation and estimation needs to be grounded on a good understanding of measurement and error. Statistical reasoning is also used in some workplaces (e.g. monitoring the quality of a product) but this looks very different to the formal procedures that students encounter in the classroom. For the workplace, exploratory and descriptive techniques appear to be often more important than the use of formal statistical tests.

In some cases workers were not conscious of using mathematical skills at work, even when they use them frequently. The way in which the mathematics is bound up with factors specific to a task can make it hard to identify the mathematical skills they are using. The other issue is that in many cases the skills workers were using did not resemble the *'mathematics they did at school'*, and so are not appreciated or recognised as mathematics.

The consciousness of the use of mathematical skills was more obvious in some companies than in others as outlined by the mixed reports of teachers during the observation process.

All workers are conscious of using Maths on a daily basis.

Drafters not only have a consciousness of using mathematical skills but they are acutely aware of the necessity of ensuring that all Maths that is used is conducted with the highest level of rigour and accuracy. This was clearly apparent during the work-shadowing process.

Many of the mathematical related tasks that the diesel fitters used were taken for granted and they did not fully appreciate the Mathematics that they were doing or where they had learnt it – to them they just did it.

The worker was adamant that he did not use any Mathematics in his job except perhaps measurement and calculation of weights - he was surprised when I pointed out that Problem Solving was part of

i The Use of Mathematics in Workplace Health and Safety (WHS)

There were strong indications from the study that mathematical skills play an important role in WHS. Individual judgements are constantly made by workers in relation to tasks with an occupational health and safety risk component.

OHS are important on-site where people need to be aware of clearance heights and walkway widths for Safety – *Quality Control Coordinator SA*

Many of the worksites were 'high tech' and automated - safety is paramount and WHS guidelines are integrated into all aspects of operations (e.g. factory layout, line procedures and processes) to the point where most workers were able to articulate how mathematics related to WHS.

WHS- statistics of near misses, fatalities and lost time are captured to help the business analyse how injuries can be prevented and thus lost time minimized – *Workshop Manager NSW*

Some companies saw WHS as the direct prevention of accidents as the focus of analyzing mathematical information.

A number of companies took a broader or more long-term stance, identifying the interpretation and/or analysis of data in tables, charts and graphs and the recognition of patterns and trends as the important mathematical related skills in this area

Checking that structures are being built with enough distance away from other obstacle and / or structures as per the Australian Standards requirements; Structures were clear of overhead obstacles; when using scaffolding, which the correct procedures were adhered to when working at heights; trench depths were measured and constructed in accordance with the correct specifications - *Quality Control Coordinator SA*

Safety is paramount at this workplace not only in relation to occupational health and safety processes but also in connection to the product and its use in the future. A safety factor is embedded in all steps of the manufacturing process. There is a safety factor formula that is applied to ensure optimum strength and longevity of the product - *Tradesman QLD*

Strong measurement abilities are needed in the area of OH & S, particularly in the area of weights and lifting – i.e. Can this motor fit in the space provided? In the building itself? How many employees needed to transport? 1 to 4 ratio for ladder use, space needed around machinery for safety, use of trigonometry for correct lengths (cherry picker/lift) and gradient knowledge for set up situations etc. – *Diesel Fitter NT*

ii. Mathematics in Quality Processes

A significant number of companies were also concerned with quality, continuous improvement and reducing waste. They have implemented rigorous quality processes whilst having to balance the benefits of higher quality against the costs of implementation. The use of mathematics is also considered important in these processes.

In quality-looking at what we can tweak or improve on a product or process to refine that product or reduce the variation, performance subject to statistical variation as we analyze the previous units, what units lead to that variation, trying to reduce the variation and the numbers with a smaller margin because that will lead to financial reward. Little variation means lower amounts of material, financial reward and greenhouse gases reduced. This requires the competent use and analysis of statistics – *Energy Analyst ACT*

Quality Control when related to *Maths in Drafting* is very important as the drawings need to be accurate and thoroughly checked so that all dimensions, specifications and any aspect of the drawing has been completed with respect to the Australian Standards - *Quality Control Coordinator SA*

The quality of the product is imperative to this company and its reputation and the nature of the product relies on numbers. The quality of a product relies on the quality of the material. Numbers need to calculated and compared to ensure compatibility – *Director QLD*

The mathematical skills, (predominantly problem solving) related to routine fault finding investigations and the quality of the service provided to Company customers. Technicians are taught that, and the Company values, quality service and problem resolution as imperative for their customers – *Solutions Manager ACT*

Responsibilities in these areas are now being delegated to lower-level workers wherever possible. Accompanying these practices is an increase of documentation with leading hands or team leaders given more paper work, being expected to read and interpret manufacturers' specifications and tolerance limits for equipment, completing daily progress charts, preparing reports, and needing to communicate with others about their observations and reports.

iii Mathematics and Technology in the Workplace

Observations suggest that most of the workplaces are now technology-rich environments. Many workers are engaged with technology, particularly in using spreadsheets and graphical outputs. There was a range of ways in which technology was used by companies, varying from total automation of a process to use in monitoring routine operations, through to use as a modelling tool for the design and redesign of products and processes.

The general perception is that technology is transforming workplace practices and the skills required. It is the view of managers and supervisors that the use of technology has changed the nature of the mathematical skills required, while not reducing the need for mathematics. Through changes in technology, mathematics has become more embedded in the role of the workers.

The use of Technology is changing the role of some workers who are using mathematics skills that they didn't require in the past. For example technicians can enter quality control data directly into centralised databases, whereas in the past this information was manually recorded and processed elsewhere by administrative or management staff.

Computerised measurements and specification charts are replacing instinct and experience. For example when mechanics are making judgements about a trucks performance they need to be more efficient and to multi-task and are using Technology to follow circuit diagrams; to diagnose faults; to consult and interpret manufacturers' specification tables and charts; and to balance when to cut losses by deciding a repair is not cost-effective and instead replacing the component or vehicle.

I'm finding my work is always changing and evolving according to the needs of the customers. We change presentations to customers to improve their understanding (of their systems/power consumption/energy efficiency). We develop new reporting tools- adding 'base load' improvements (more accurate reporting e.g. air conditioning response to temperature by time of day). We support 'Greenbuild' (environmentally sustainable) processes by way of BMS, which slip over the top of basic reporting – *Solutions Manager ACT*

All staff are issued laptops and are expected to be computer literate – including how to navigate the Company's system and specialist programs such as - sub-contractor quotes, parts/costing spreadsheets, excel, CAD drawing, customer reporting, data reporting processes - *Project Manager ACT*

There is a drive to use a mobile phone based application for recording OHS issues and incidents for every job. These are then compiled into monthly reports – *Service Delivery*

The examples below demonstrate how the extensive use of technology in the workplace has changed not only the way that work is done, but also the work itself. More sophisticated analyses are now required and workers need to be more mathematically competent in order to understand and interpret the information produced by these analyses

Computers and Maths go "hand-in-hand" in this business. The Managers use Computers and Maths skills daily. Examples include: Billing time for Work in hours / rate per hour; Percentage of Time working on Mechanical versus Electrical versus Structural; Percentage of Time for Sick days by Drafters; Percentage of Cost of a Job for Profit versus Cost; Use of Spreadsheets for many Financial aspects of the Business including Balance Sheets; Use Computers with a colour scheme to indicate the Hours spent on a Job e.g. Yellow for up to 75% of Time allocated to the Job; Red if the Job goes over the allocated Time; Use CADFLOW for reporting of data including Performance Figures for the Company; Cash Flow; Calculation of Gross Profit Margin; Billing ratios – e.g.: 85% of hours will be sold at the beginning of the year. Check every week, looking for "trending information" that is reflective of the Company's financial position – *Managing Director NSW*
This is our "whole Job." Use of computers with maths is how drawing is now done – *Trainee Drafter SA*
Measurement is essential especially when communicating with Engineers or on-site. Computers assist with this as it provides the accuracy needed for the quality of the design. CAD incorporates the Maths in its software which makes everything we do as accurate as possible – *Design Drafter SA*
However, as more vehicles are fitted with various ECM's (Electronic Control Module's) there will continue to be an increase in the use of technology and the mathematical skills required to analyse the data that is produced and problem solve to come up with solutions as to how various issues can be rectified. Technology is also used in the conversion of units e.g. lbs to kg, kPa to psi. The primary function of the ECM is to - control the engine's performance, fuel efficiency and emissions, safeguard the engine from abuse, troubleshoot mechanical problems, and to monitor the operation of the vehicle. Technicians need to have experience using ECM data in the analyses of their trucks – *Training Coordinator NT*
Computer knowledge and use is essential for technicians. In addition to Excel, technicians are required to operate software where formulas are used to make complicated and repeated calculations programing the operation systems used by the company. Again the importance of knowing and understanding how these formulas actually work was stressed. The Company also develops, or outsources, templates for employees to use for quality control in finance, quotation, auditing processes, and after hours reporting. The ability to find faults in a maintenance system relies on reverse engineering techniques – working backwards to find a problem, this process can involve tracing/retracing formulas, tracing/retracing flowcharts, diagram and graph interpretation. Attendance at after hour faults can require delivery of quotations for parts and work to a customer which can involve all basic mathematical calculations, both with and without calculators, including percentages and proportion (given a particular input what should be the proportional output? Most systems not just no/off (0/1) but a range from 0-10 – Proportion Integral Control), input□proportional output, reset loops, looping program to control device using floating control, accumulating metre data (pulse ratio) in the field, air flow set points. In addition, the majority of problems in the air conditioning systems involve the measurement concepts of air flow to volumes (zones) – *Project Manager ACT*
Workers now need experience in using spreadsheets - time sheets are now electronic. The algorithms consultants use are becoming more intensive and sophisticated. Expectations are that we are able to produce more meaningful reports – *Workshop Manager NSW*
You need a lot of maths skills, and to be able to use maths based software (graphs and charts, spreadsheets, remote data acquisition, scale drawings and schematics. Need to be able to 'read' symbols of systems to do analysis. The company is an information based company, and the use of computers is essential to the operation of the business. Computers are used for planning "Building Management Systems"(BMS) Estimations for design are based on previous experience and expertise, backed up by real data (from current systems). Used for quoting for new business. Measuring ongoing operation and efficiency against benchmarks – *Solutions Manager ACT*
The introduction of computer aided design (CAD) has substantially increased technology within manufacturing, reducing development costs and wastage, and changing the required types of mathematical engagement For example, the existence of CAD/CAM software means that more complex products can be visualised, producing a need for new IT/visualisation skills – *Draftsman QLD*

The study did find examples of people in the workplace who lacked the mathematical knowledge to understand fully the techniques they are using, to control the technology, and to understand and use the outputs.

> **Spread sheets are used within certain departments of this workplace but would be used extensively if employees came armed with the knowledge and understanding of how to use them. Many employees are coming without the ability to apply mathematics to a spread sheet. They are unaware of the general equations that can be used to make mathematics simple and applicable to various contexts. They are also unable to understand and analyse data. Creating formulas for spread sheets can be complicated and the employer is not expecting all employees to be able do this. He would however like employees to come equipped with an understanding of the basics of spread sheets. For example how to use Excel to do calculations and KPI sheets for averages – *Director QLD***

Other companies also pointed out that the impacts of technological change may be dependent on the skill level of employees. Some companies found it important to emphasise that a lack of understanding of how technology and mathematical skills are interdependent can lead to ineffective practices. Over-simplistic assumptions about education in this area can mean that only fragmented procedural skills and techniques are taught (e.g. training in the use of software packages being largely procedural). They suggest that this issue needs to be addressed in the development of future education and training provision

It therefore seems that an important consideration in the structuring of curriculum and teaching approaches is how to embed digital technologies so that they are not seen as optional tools. As pointed out in the development of the Australian Curriculum: Mathematics - *Digital technologies allow new approaches to explaining and presenting mathematics, as well as assisting in connecting representations and thus deepening understanding. Digital technologies can make previously inaccessible mathematics accessible, and enhance the potential for teachers to make mathematics interesting to more students, including the use of realistic data and examples.*

d. The Application of Mathematics in the Workplace

From the observations of teachers the application of mathematics in the workplace can be categorised as either being used in routine processes or evident in more sophisticated use of 'basic' mathematical skills in more complex or multi-functional tasks.

i Mathematics in Routine Applications

There were examples observed of workers involved in the rote performance of procedures without understanding – they had no clear understanding of the result, only that 'it works'. In spite of their lack of understanding of the mathematical reasoning in familiar and routine settings, it was noted that workers were able to use fundamental mathematics confidently – even though they didn't recognise it themselves often because procedures have been developed that support and enable routine calculations. In many cases digital readouts with decimal displays, simplified diagrams and pre-calculated amounts of chemicals listed on charts rather than relying on workers using ratio and proportion computations give workers the impression that they are performing nothing more than routine measurement tasks. In these cases the workers considered that they did little more than "basic" arithmetic without thought - making it appear non-mathematical to them.

The mathematical work could be considered to be of a routine nature as it involves the custom measurement in the manufacture of existing parts – *Draftsman QLD*

Nearly all routine processes within this workplace require the use of mathematical skills. This workplace uses many machines that are driven by computers and programs that are number generated so its just a case of – *just doing it. - Tradesman QLD*

However, there were examples of workers using mathematics to solve workplace problems within routine operations. One point, which was frequently made was that even in routine tasks there was a need for workers to recognise immediately that a particular piece of mathematical information was implausible and possibly just wrong. This kind of judgement requires a combined appreciation of mathematics and the context and content of the work task. There were also examples where workers who thought that they were performing routine operations were actually using a range of mathematical skills. For example, to maintain factory machinery in good order there was a need for both routine and emergency maintenance, where the skills demanded are multi-faceted, including recognising when action must be taken, often on the basis of mathematical information. Another example was the replacement of worn machine parts in a case that requires conversion between units and interpreting diagrams. In one company there was a need continuously to keep track of stock with limited shelf life, which required systematic data-entry and monitoring.

ii The application of mathematics in complex tasks

The study found many examples where workplace mathematics went beyond the procedural use of mathematical skills, to its application in situations which related to changing circumstances or to initiate quality improvements.

In these situations workers tended to use skills which might be described as 'judgement' or 'problem-solving' which went beyond the routine numeracy-based procedures. In these cases the application of mathematics in the workplace is much more than a set of simple and disconnected skills and it goes well beyond a command of 'fundamental' mathematical content. The requirement to perform these more sophisticated functions requires workers who are confident to use mathematical skills in problem-solving situations and can see the consequences of the mathematics - related procedures.

***An Instrumentation Apprentice* working in a Measurement Products Factory – has to check whether flow meters are operating correctly and then calibrating the meters (Flow meters are a device which measure fluid/gas flow) This involves;**

- **Measuring the liquid (water in this case) using the flow meter in litres**
- **Comparing the same liquid in the weight tank in kg -scale of weight tank is in kg and can be incremented by 1000 kg**
- **Aligning the weight tank after all measurements are done**
- **Performing 6 runs of the amount are made before final measurements taken**
- **Look for what is the error between what water is actually going through and what is being measured by flow meter - - Using weight as the true reference**
- **Excel sheet is used for Converting kg to L (air buoyancy calculation). Enter current temperature into spread sheet provides factor to multiply to convert kg to L.**
- **Compare calculated L in weight tank to L counted by flow meter.**
- **Manual table used to record all the various progressions and signed off on**

This process requires the understanding and application of the following Mathematical concepts;

- **Percentages**
- **Scale reading**
- **Basic operations**
- **Capacity and volume**
- **Rate conversions**
- **Use of formulae**
- **Extrapolation**
- **Interpretation of data**
- **Using formula**

In the Manufacturing section of the company a Technician has to test the Switchgear produced for Mining companies – this includes the function checking of a panel which involves;

- **Going through a schematic (plan) and Testing a circuit**
- **Looking at terminal layout in the circuit and check solid bridges in the terminal and ensure the schematic no of bridges match the no of bridges on the terminal layout of the circuit**
- **Checking for the right bridge in the right place - If the no of bridges doesn't match the no on the circuit then a report has to be filled out-called an NCR (Non-Compliance Report), using Excel**
- **Recording whether the bridge as too short or too long**
- **Solid bridge instrument used to measure the bridges-comes with the plan and the circuit**
- **Use the CT (Current Transformer) to convert to a safety reading**
- **Use formulas when transforming the voltage so you know how many amps to inject to make phase A neutral which is the first of three phases**
- **Convert from one phase to another**

This process requires the understanding and application of the following Mathematical concepts;

- **Percentages**
- **Ratios**
- **Plan reading**
- **Patterns recognition**
- **Operations**
- **Use of formulas**

These examples indicate how workplace mathematics is carried out in ways that are very different to how mathematics is taught in schools. It indicates that alongside the need to know how to calculate and estimate and to have a feel for numbers, percentages and proportions there is an understanding of the 'modelling' side of mathematics. The mathematics is entrenched real data and involves an appreciation of the constraints of a mathematical model, flexibility in understanding different representations of the model and being able to modify the model to improve workplace practice and outcomes.

Across the case studies there were a range of examples that required this sophisticated use of 'fundamental' mathematical skills - particularly when people in the workplace were faced with modelling scenarios. These situations required the application of a mixture or blend of mathematical skills (for example, good technical and mathematical knowledge combined with ability to communicate analytical information).

Within this division the majority of the work is based on fault finding and these processes have very strong links to mathematical ways of thinking – or problem solving strategies, logical processes and communication of these to the customers concerned. The *Service Delivery Manager* stressed the importance of employees being able to problem solve in a logical way, being able to complete those processes in a time constraint situation and then communicate the problem and proposed solution in an articulate manner to superiors and the customer in the workplace. He indicated that mathematical ways of thinking were continually being used by technicians in his area, sometimes without them realising that they were doing so.

Examples like the one above, where a mixture of mathematical skills and understandings were used in an integrated approach, with their use framed by the work situation and practice, were common observations. The range of mathematical skills and understandings included:

- integrated mathematics and technology skills
- an ability to create a formula (using a spreadsheet if necessary)
- proportional reasoning and calculating and understanding percentages correctly
- modelling, including understanding thresholds and constraints
- using extrapolation and extrapolating trends
- recognising anomalies and errors
- communicating mathematics to other users and interpreting the mathematics of other users
- an ability to cope with the unexpected
- fast and often multi-step calculations and estimations
- Interpreting, and transforming between, different representations of numerical data (graphical and symbolic)
- systematic and precise data-entry techniques and monitoring
- concise and clear communication of judgements

The blended or integrated use of these skills is central to the type of mathematics required in today's workplaces and in many cases it is recognised to be a significant deficit in the skills of young people entering the workforce. Some workers are extremely competent in applying mathematics to solve problems in these sophisticated ways. Many others encounter difficulties. Some, but not all, of these difficulties are due to poor mathematical understanding. In many cases, it is the application of mathematics in the workplace that causes difficulties.

For example the fact that problem-solving has been identified as a skill needed for workers, and is popularly used to justify the inclusion of mathematical problem-solving in the school curriculum, some teachers observed that, in fact, problem-solving in the workplace differs significantly from that taught at school.

When I pointed out that many of the "Problem Solving "techniques they were using such as;

- **Systematic lists**
- **Draw a diagram or make a model**
- **Look for a pattern**
- **Compare to a similar problem that they have already solved**

are now taught in school they were surprised

Teacher Observation NSW

One aspect of difference is the motivation for undertaking the task - since problem-solving in the workplace is focused on a practical outcome, rather than being an end in itself or generating further mathematical knowledge. In addition, in a work situation the problem is usually 'owned' by, and has meaning for the worker, rather than being presented by a teacher. In school mathematics problems have correct solutions, and there are no real consequences if a wrong answer is given. However, in the workplace, incorrect solutions can have serious and costly consequences, while the degree of accuracy or exactness of the outcome is not absolute, but negotiable according to the circumstances.

e. Relationship between workplace mathematics and school mathematics

i Relevance of School Mathematics

As pointed out earlier, the level of mathematics used by people in the workplace, and required by employers for all but the most highly numerate and technical jobs can be described as 'fundamental' mathematics that is sometimes applied in complex situations. Although the content is largely covered in the curriculum it is the application of the mathematical content to the workplace that is not straightforward.

The study was used to examine how workers relate the mathematics skills they learnt at school to how they use them at work.

There were many links between school and workplace mathematics such as:

- **Unit conversion and using different units of measure**
- **Calculating volume and weight**
- **Reading values off graphs and tables**
- **Analysing statistical data**
- **Mental arithmetic**
- **Reading and interpreting scale drawings, plans and diagrams; especially technical and exploded views**
- **Substituting values in to formulas**
- **Angle facts and relationships**
- **Ratios**
- **Circle facts and calculations**

Training Coordinator NT

All of the mathematics used by the two workers is taught in our schools. What is not taught is the application of this mathematics, for example the calculations of temperatures for heat treatment of metal involve simple measurement and computation techniques. How to use these for the application at hand is new. Also calculation of bend creep involves mathematics taught at school, it is the application to the problem of metal stretching as it is folded that is new

Observation of Apprentices NSW

The feelings of the workers interviewed about the usefulness of school mathematics varied from seeing absolutely no connection to the maths used at work to identifying the relevance and transferability of some school maths skills from their school experience.

This is one of the most interesting aspects / concepts of this Project. The relationship between workplace mathematical skills and school mathematics could best described as "distant" at best.
Teacher Observation

On a scale of 1-10 where 10 was the highest, the workers rated the usefulness of school mathematics at about 6. They felt that while the mathematics may have been relevant the delivery was lacking to the point that at the time they felt that it was uninteresting and irrelevant
Teacher Observation

It may be the lack of relevance or connection to the worker's workplace realities that led to observations from workers that the maths taught in school is not really relevant when required in workplace situations. The following were recorded by teachers in their observations of apprentices and technicians.

Maths topics such as Measurement, Calculation, Estimation and Trigonometry & Pythagoras are used in Drafting. The basic principles have been taught at school however there is little, if any, "real life" examples / scenarios that connect and / or accentuate the relevance of these Maths concepts in the workplace. The "basics" have been identified as a "main stay" & fundamental to being able to competently conduct drafting. From the responses in the interviews and work-shadowing it was clearly evident that these maths skills are fundamental to work and hold great importance when functioning as a drafter.
In most cases the workers maintained that the majority of their mathematical skills were learned after leaving school but it was obvious that that much of the numeracy and measurement were concepts taught at school.
Generally the workers said that they learnt most of their skills, including mathematical skills either at TAFE or "on the job"
Many of the workers complained of boredom in high school mathematics and all of us as teachers have heard the comment "when am I ever going to use this". If instead of just teaching the mathematical tools we could also teach our students how to use them we might have more success and more satisfied students.
Of most importance to my mind is the problem solving aspect; the application of existing knowledge to solve an unfamiliar problem. This is one of the four proficiency strands in the Australian Curriculum yet it appears many young people are entering the work force without this skill. Some develop it quite quickly once on the job but others would benefit from a formal training
However, the Maths that was taught in the classroom, in the main, was not linked to real-world applications, therefore no relevance or importance was seen to the Maths they were studying in the classroom.
They couldn't see why it was important to give answers accurately, or what values really meant when substituting into a formula.
When these students reached the workplace, the company gave them the reason and applications of these mathematical skills which in the past they had found dry, boring and irrelevant.
All employees that I observed/ interviewed said that although they did learn some of the mathematics they use at work at school they learnt more on the job. As one employee said," I knew about maths but I didn't understand it or how it could apply to the work I would do in the "future".
The general consensus of employees was that there needed to be more real life mathematics in schools. For example: conversions from imperial to metric, trade knowledge like the fact that pricing in the manufacturing industry does not mention GST, reading of graphs, an understanding of spread sheets and how to use them for the subsequent analysis of data and the ability to interpret diagrams and tables.
Re-Engineering Australia (REA) Foundation's F1 Program got mentioned several times as the company is involved with the project and can see the links that it makes between workplace mathematics and school mathematics.

The conclusion to be drawn from these comments is that, to avoid lack of relevance mathematics needs to be made relevant to the learners. Mathematical understanding is important and the study has highlighted the importance of particular mathematical topics but the observations of workers emphasises that the problem is more about how mathematics is taught and learnt at school rather than the content of the curriculum. Mathematical content it is not on its own sufficient for students to successfully develop mathematical competence for the workplace. In part, this is because, as has already been discussed, the ways in which mathematics is applied at work are very different to school mathematics.

Employers should not expect young people fresh out of formal education to operate like experienced workers but educators should recognise the importance of giving students experience with multi-step, data-dependent operations – *Managing Director SA*

ii The mathematics skills employers look for in recruitment

Managers interviewed through the case studies were generally very aware of the potential value and importance of mathematics skills for their workforce - although they varied in how formally they referred to them explicitly in recruitment.

It was common to set different criteria for professional (i.e. higher education qualified) or non-professional staff:

- Professional: few companies specified a mathematical qualification as such, instead inferring sufficient mathematical ability from degree attainment in the professional qualification.
- Non-professional: it was common to ask for Yr. 12 Mathematics and to require satisfactory performance on a basic numeracy or quantitative reasoning test administered as part of the selection process.

Some employers are rethinking their recruitment policies and on-the-job training schemes as a result of a perceived need for higher levels of mathematical competence and the changing mathematical requirements of the workplace, as described earlier. Several companies commented on the need to either hire people who are already in possession of skills or able to develop these skills quite quickly through training, whereas in the past they might have relied on developing employee's skills over time within the organisation.

When hiring new staff the main abilities that are considered include;

- **Mechanical Reasoning**
- **Basic Literacy and Numeracy**
- **Spatial Awareness**
- **Manual Dexterity**

Maintenance Engineer NSW

The company has many thousand apprenticeship applications each year but they will only employ six to twelve of them. Various skills of a young person are taken in to consideration when hiring new staff, especially Mathematics. Their ability in Mathematics - especially mental arithmetic is very important. The applicants undertake a test with questions about topics such as: Addition/Subtraction/Volume

Training Coordinator NT

Although the range of views and practices in relation to formal testing of mathematical skills are diverse across companies – there is an understanding that they are important considerations when hiring staff.

Maths skills" were not a high priority in hiring new Staff although the Manager did mention that a sound knowledge of "Basic Maths" was important. The main Maths skill that he identified was a form of "Mental Maths" which is 3D Visualisation for Design Drafting. He said that he wouldn't necessarily get new Staff to undertake a "Maths Test" however he would consider talking with a person about 3D perspectives and that a person would be preferred if they had the ability to think & visualise in a 3D perspective. Having undertaken CAD at School would be a "must" and the ability to explore things in 3D would be advantageous. Having the ability to understand and apply the concepts related to Spatial Awareness was important also. The prospective employee could bring in work that they had completed using CAD and be able to talk through the process of how they were able to design draw

Managing Director SA

It is expected that apprentices learn the fundamentals at school and come to the company at a certain level, hence why they have tests and an interview. The company regard school mathematics as the most important part of a person's learning

Training Coordinator NSW

Companies hiring apprentices also expect that potential applicants will satisfy basic numeracy requirements and they are often required to sit short written tests examining standard workplace numeracy requirements.

How are they measured?

- **Aptitude Test**
- **Numeracy test**
- **Psychiatric Test**

Training Coordinator NSW

The Company utilises a Group Training Company to recruit for apprenticeships each year, using competency based testing in Mathematics (calculator and non-calculator components), English and Spatial Awareness followed up with the interview process. The testing process is completed under time constraints to further ascertain if applicants are able to withstand this additional pressure

Service Delivery Manager ACT

Some managers and supervisors associated with the selection and training of apprentices have been alarmed at the decline of job seekers' knowledge of basic mathematics which is required to pass any pre-employment aptitude test.

Another point of concern raised by some of them was the difficulty of using school reporting on mathematics as clear and/or reliable indicators of competency in the recruitment process. Some companies have responded to this by administering entry tests, and being more selective about the reports which they accept from job applicants. In principle, it is desirable that employers should have a better understanding of the mathematics experienced in schools but they are unlikely to do so if frequent and rapid changes in curriculum structure and content continue to occur. It is evident in the case study data that the information some employers would like is not being satisfactorily communicated to them by the education sector.

These employers do have a notion of the standard of mathematics that they are looking for: understanding this more exactly, and determining how educators could better communicate information about it, requires further investigation. The Australian Core Skills Framework (ACSF) provides a consistent national approach to the identification of language, literacy and numeracy skills requirements in diverse work, training, personal and community contexts. It is a common reference point for describing and discussing performance within the five core skill areas of Learning, Reading, Writing, Oral Communication and Numeracy. Therefore we need to consider how competence in the application of this content can best be developed and reported in mathematics education.

iii Development of mathematical skills in the workplace

Most workers were very clear that they preferred to learn on the job through demonstrations by fellow workers, team leaders or technical staff from other departments, with ongoing support and the opportunity to ask for further assistance if needed. Interviews with workers during the case studies certainly corroborated workers' preferences for practical learning strategies.

No one interviewed within the companies was enthusiastic about learning in a classroom setting.

How do your workers learn any new math's skills they need? The preferred models include;

- **watching another worker/ Mentoring**
- **explanation by supervisor, mentor or colleague**

Training Coordinator NT

The support of acquisition & development of Maths Skills in the workplace is undertaken by watching others and through communication with mentors & colleagues. The Mentor system allows for experienced workers to team with or buddy up with new workers and together the Maths skills are passed on. The working environment is good for communication between workers so that there is regular contact and through questioning and answering, learning of Maths skills takes place. Knowledge Sharing in all areas & specifically in relation to Maths is common and in many cases, a daily occurrence. These are the most effective Models of Training that the company uses

Design Drafter SA

In-house Training and simulated training environments also had a place in workplace training, depending on the type of task or learning that was required

The Company has a web based training program which is available to anyone wanting to build their skills in areas associated with company's core business. There is a strong focus on the mathematics associated with controls, BMS, energy efficiency and energy assessment
Solutions Manager ACT

There are various forms of training within the company , such as:

- **Training at the work place – where they go through mathematical processes**
- **Watching another worker (shadowing)– diesel fitters show new skills to their colleagues and the apprentices**
- **Explanation by supervisor, mentor or colleague –the company has their own training coordinator who works with about 30 apprentices, giving them training such as: competency requirements, safety training and basic training in mathematics.**
- **Other – apprentices and workers wanting to improve their knowledge and skills are expected to read the relevant manuals.**

Training Coordinator NT

Many workers indicated that if formal training/teaching is to be used, it needs to be less 'school-like' and 'not in a classroom'. Furthermore, it was important to them not to create an environment reminiscent of school mathematics.

The implications for teaching are that mathematics skills/concepts should not be taught as discretely defined objects – it needs to reflect the long and problematic experiential processes. Teaching approaches need to reflect the application of a range of mathematical concepts integrated with a detailed understanding of the particular workplace context rather than decontextualised mathematical skills.

iv Transfer of mathematical skills

Concerns relating to the difficulty of transfer of mathematical skills from one context to another prompted the study to examine this issue with the workers during the shadowing and interview processes. For some workers, the unconscious use of mathematical skills made it difficult to explore questions of transfer. The findings relating to transfer from school to work were not clear cut.

The apprentice, who had the least mathematical training from the school environment, initially had difficulty realising that the skills he was using transferred from his time at school. The other two employees however, became aware of how all the skills they learnt in the school environment transferred to their workplace environment once they had adjusted and practiced on the job.
Apprentices NSW

As daily percentage work drives the air conditioning side of the business, all technicians were aware of the relevance of any work they completed in this area during their schooling. All were also aware of the work they completed in rates and ratios and measurement (particularly volumes, and surface area) at school transferred directly across to their workplace
Project Engineer NSW

There was also evidence that the transfer of skills and knowledge was more successful when it took place between different workplace situations. Workers felt that they learned the basics in one place and adjusted or built on them in other workplace situations as outlined in the teacher observations below.

Many skills were transferable, helped by the core principals being consistent for different types of vehicles. When new skills had to be learnt it was easier to add to the knowledge, in a real context, that they had.

Most employees are trained in one specific domain so they know their tasks thoroughly. I saw one employee transfer his knowledge of skills from one machine and its programming to another machine and its programming. The draftsman uses his knowledge of formulas to work on many designs because he is transferring the skill to a familiar situation in the workplace

Both workers were in previous employment including building trades apprenticeships, and the military. I had the feeling that they attributed their knowledge and skill to these earlier experiences rather than to anything they may have learnt at school. The participants felt that their skills would be readily transferable to other industries. Examples included maritime repair, boiler making, fitting and turning and cabinet making. This transferability of skills was very important to them

This ability to make links between different workplace situations highlighted:

- The importance of the connection between workers' awareness of their mathematical skills and new applications in the workplace. The workers were able to reflect on, and describe, the mathematical related skills they had developed in the workplace and were confident in their ability to adjust their transfer to other workplace situations.
- That the transfer of skills was probably due to the fact that often the tasks involved were procedural in nature – i.e. steps of operation are in sequence with the sequence of steps repeated every time the task is performed. This type of procedural training is relatively easy to learn and transfer in the rate of application is usually high, but the question is whether the worker is likely to adapt the skills and knowledge when confronted with new environment and changed conditions.

The challenge for mathematics in schools is how to apply what is learnt in different contexts and to recognise and extend this learning to new situations – i.e. learning new skills or performing new tasks in situations that differ significantly from the situations of learning mathematics in schools. To promote this type of transfer will require teaching approaches that allow learners to adapt the acquired mathematical knowledge and skills to perform or learn in changed situations or new environments. This goes beyond repetitive application of learned behaviour and involves cognition and analogy to adapt to new challenges. Transfer of learning from this type of teaching is difficult but more important from the perspectives of transferring and applying mathematical skills in the workplace. The challenge is to identify the characteristics of teaching and learning that positively affect this type of transfer including:

- How can the prior mathematics learning of students be recognised, and connected to a workplace situation?
- Identification of teaching and learning strategies for transfer – e.g. problem solving and inquiry-based methods; curriculum providing for a range of contexts.

f. Summary - *the mismatch between young peoples' mathematics skills and the expectations of modern workplaces*

The sample of companies examined in the research study cannot be regarded as fully representative of all industry sectors. Nonetheless the study revealed some significant features of workplace mathematics that is not generally reflected in school mathematics. The following mismatches were identified as common trends emerging from the study:

- Unlike classroom mathematics, where mathematical practices are clearly identifiable, workplace mathematics is embedded in specific roles, tasks and goals. As such workplace mathematics can often only be understood in context. Indeed, because they involve work specific conventions and sometimes break the 'rules' of mathematics, young people will often struggle to make sense of how mathematics is carried out - which we believe has considerable implications for how mathematics is taught. In summary, the key themes that were reinforced from the study are that:
  - Workplace mathematics is highly contextualised and hard to recognise as mathematics when taken out of workplace context or task.
  - There are often many equally valid ways of arriving at the answer to a mathematical problem in the workplace.
  - Completing mathematical tasks in the workplace is more complex that just performing the calculations.

- The level of mathematics used by people in the workplace and required by employers for all but the most highly numerate and technical jobs involve *'core'* mathematical content and concepts. In general, students would have already covered the critical mathematical techniques and concepts through the school the curriculum (through, for example the General or Essential mathematics subjects in the senior years).

- Although the mathematical content may be at this level, it is embedded within complex settings and the application of *'*core' mathematical techniques is not straightforward. It often involves the use of technology and is more often than not used in collaboration with others. People in the workplace need to choose the appropriate mathematics, sometimes under pressure. They then need to apply it, and make informed judgements using the results. All this is central to the type of mathematics practised in workplaces today and in some cases was recognised to be a significant deficit in the skills of young people entering the workplace.

- Beyond the procedural use of mathematics in routine operations, the competent use of mathematics in the workplace is not just about being able to do 'core' mathematics - but about knowing which mathematics to use and being able to construct appropriate models and interpret and communicate the results. Mathematical understanding is important and the research has highlighted the importance of particular mathematical topics/content. However, this content on its own is not sufficient for students to successfully develop mathematical competence in the workplace. In part, this is because the ways in which mathematics is applied at work is very different to school mathematics. The competent use of mathematical skills is challenged when people in the workplace are faced with unexpected problems – and are forced into confronting mathematics with which they would not usually engage on a day-to-day basis.

For many workers this is in part, because the ways in which mathematics is applied at work, looks very different for them to school mathematics. The emphases is less about mathematical and calculation skills narrowly and more about how mathematics is applied and interpreted.

- Much of the workplace mathematics is not a solitary activity but it involves collaboration at different levels - either with people in the workplace coming together as a team or where employees with responsibility for specific processes bring these together to create whole products. Increased teamwork requires workers to develop and exercise a wider range of skills, e.g. planning, budgeting, scheduling, and process control. Collaboration in the form of teamwork is particularly important in that it enables participants to build a strong shared understanding of the mathematics they are engaged in and this approach should underlie mathematics provision in schools.

- One point, which recurred frequently in the case studies, was the need for workers to recognise immediately that a particular piece of mathematical information was implausible and possibly just wrong. This kind of judgement (that could be referred to as 'questioning the numbers/data') requires a combined appreciation of mathematics and the context and content of the work practice. It was important that education provision recognises this fundamental fact.

- The need to understand and apply a blend of skills was seen as a key requirement for workers to use mathematics competently. Workers need to both understand the mathematical content and have the capacity to understand it within their workplace. This understanding needs to include making sense of a problem, interpretation and communication. Neither mathematical understanding nor the application capacities are sufficient on their own. This has implications for the content and structure of both education and training. The sense is that workers need a blend of the following;
  - an understanding of the mathematical concepts, procedures and skills;
  - an understanding of the kinds of practical tasks they need to perform; and
  - the strategic processes they should be able to use in applying mathematics.

  Current teaching approaches generally tend to emphasise these separately. This is an observation about connections - in the workplace the mathematical skills are placed into a mathematical 'whole' (the process), but that is also embedded in (i.e. connected to) a context. Neither form of these two types of connections are emphasised nearly enough in school maths.

- Employers do not expect young people fresh out of formal education to operate like experienced workers, but emphasise that educators should recognise the importance of giving students experience with multi-step, data-dependent operations. The relevant mathematical understanding is best developed through the use of problem solving techniques and a consideration of mathematics in context**.**

- Many people in the workplace regularly engage with technology, particularly in using spreadsheets and graphical outputs. However, the study has identified examples of people in the workplace who lack the mathematical skills to understand fully the techniques they are using, to control the technology or to understand and use the outputs.

- School reporting on mathematics. Employers do have a sense of the standard of mathematics that they are looking for in recruitment. Understanding this more exactly and determining how educators could better communicate information about it requires further investigation.

4. Implications for teaching and learning mathematics

a. How we can better match classroom learning and workplace needs

As outlined earlier the gaps between young peoples' mathematical skills in the senior years of schooling and the expectations of modern workplaces is more about how mathematics is taught and learnt at school rather than the content of the curriculum. Educators therefore need to consider future practice and directions related to the development, enhancement and transference of mathematical skills to the workplace and how this can best be developed in and through school mathematics education.

It was constantly pointed out through the Research that the relevant mathematical understanding required for the workplace is best developed through the use of problem solving techniques and a consideration of mathematics in context. This should involve problem-solving opportunities involving *"messy"* contexts that do not have straightforward solutions. Students should have many more opportunities to collaborate and discuss, working together to understand, interpret and communicate the mathematics they are involved in. To do so, teachers cannot be satisfied teaching mathematical techniques alone. Focusing on the basics until students master them and only then moving on to solving interesting problems will perpetuate the mismatch between school and workplace mathematics. Although drill and practice have their place, mathematics programs need to focus on challenging problems that motivate students to acquire skills that prepare them to work in a technological and complex world of work.

Teachers need to use models, examples, or explanations that elaborate or exemplify mathematical principles and connections to the workplace - i.e. that will allow teachers to situate mathematics within contextualised practical workplace problems – entrenched in real data (e.g. in the form of data output from spreadsheet models); set in the context of the work; involving an appreciation of thresholds and constraints of a model (e.g. the limitations on factory output, the costs of machinery or throughput of production lines), flexibility in understanding different representations of the model (e.g. the columns of a spreadsheet; charts or graphs, or, less commonly, symbolic forms) and being able to modify the model to improve the simulation of workplace practices and outcomes.

Classroom activities should use workplace specific, open-ended mathematical tasks for students that:

- show relevance and relate to authentic workplace practices;
- address *'core'* mathematical concepts in complex systems;
- provide problems that have no correct solutions but require thinking and reasoning - this should involve problem-solving opportunities involving *'messy'* contexts that do not have straightforward solutions;

- provide students with opportunities to collaborate and discuss, work together to understand, interpret and communicate the mathematics they are working with; and
- teach relevant statistical modelling techniques – understanding systems, statistics, data analyses multi-step, data-dependent operations.

To allow students to more easily apply and transfer their mathematical skills into the workplace there is a need to improve a student's capability to apply and learn mathematics within the following key areas. Competence in these areas is important in the workplace through:

- responding to situations and problems;
- activating mathematical behaviours and processes when appropriate;
- mathematical modelling;
- communicating mathematics rich information; and
- transferring mathematical skills and understanding.

Each of these is elaborated below.

Responding to situations and problems - will include developing a student's capability to:

- identify or locate relevant mathematical information in the task or situation;
- act on or react to the information in the situation; and
- understand and interpret the information, and comprehend what it means or implies (e.g. whether something makes sense or is appropriate within a given context).

Activating mathematical behaviours and processes - will include developing a student's capability to:

- explore or develop the way content is applied - i.e. the thinking and doing of mathematics including concepts and procedures (both formal and informal) in areas such as arithmetic, calculations, measurement, geometry and data analysis;
- solve problems, including extracting relevant information and understanding and modelling the task (verbally, mathematically, and visually);
- being analytical;
- undertaking multi-step calculations and estimations;
- working in teams to develop and exercise a wider range of mathematical skills such as planning, budgeting, scheduling, and process control; and
- being comfortable using mathematics – building beliefs, attitudes, and background experience so they can be resourceful and self-confident in the use of mathematical techniques.

Mathematical modelling - will include developing a student's capability to -

- demonstrate an understanding of mathematical concepts, relationships and constraints;
- identify, collect, and organise mathematical information relevant to investigating and solving problems;
- recognise and apply the mathematical techniques needed when analysing and solving a problem in context;
- interpret results and reflect on the reasonableness of the conclusions in context.

Communicating mathematical information - will include developing a student's capability to -

- communicate mathematical reasoning and ideas using appropriate language and representations, such as symbols, equations, tables, and graphs;
- interpret and use appropriate mathematical terminology, symbols, and conventions;

- analyse information displayed in a variety of representations and translating information from one representation to another;
- justify the reasonableness of the results obtained through technology or other means using everyday language, when appropriate.

There is a growing need to effectively communicate to work colleagues and customers a range of information that is based on mathematical data and inferences. This includes using mathematical reasoning and ideas by using appropriate language and representations. In their preparation for work entry school students should have opportunities to read about, represent, view, listen to and discuss mathematical ideas in a range of settings, including those related to work. These opportunities should allow them to create links between their own language and ideas, the formal language and symbols of mathematics and the use of mathematics in the workplace. Communication is important in clarifying, reinforcing, and modifying ideas, attitudes, and beliefs about mathematics.

Transferring mathematical skills and understanding

Given the research finding that the transfer of mathematical skill to the workplace is not always straightforward there is a need to promote the development of mathematical skills and understandings in ways that encourage transfer. The more contexts in which mathematical skills are explicitly applied, the more highly developed they will become. To ensure that they are developed in a range of contexts, they need to be explicitly integrated into the learning outcomes and delivery strategies throughout the curriculum. For this to occur:

- Teachers must be aware of the impact that teaching and learning methodologies have on the acquisition, application and transfer of the mathematical skills and understandings. Teaching for transfer is dependent on methodologies involving the active participation of students in the learning process. Students taught to think critically and to manipulate information are better able to learn and apply key mathematical concepts. This has important implications for the professional development and networking of teaching staff to increase awareness of teaching and learning models and methods which promote transfer.
- Learners must be made aware of the application of the mathematical skills and understandings in each new context to ensure that transfer will occur. Learners must be able to make connections between what they learn in a classroom and what will be required on the job. Learning strategies which make transparent the linkages to the workplace and other contexts are more likely to lead to successful transfer of the skills and knowledge learnt in mathematics education
- Mathematical skills and understandings must be developed in a way which enables them to be applied outside of the mathematics classroom, such as in the workplace. If young people are to transfer the mathematical skills learnt in the educational environment, to the workplace, they will need to be encouraged to practice them and perform them in everyday life and at work. They need to be assisted to see connections among contexts in familiar and non-familiar situations and work
- Teaching needs to promote the development of positive attitudes to mathematics and its usefulness and positive self-images as people who can do and learn mathematics as they need to, on the job and in life generally.

b. Links with development in the Australian Curriculum: Mathematics

The project conducted an examination of how curriculum frameworks or syllabuses in the jurisdictions provide the bases for courses in schools that can:

- enable students to develop work-related knowledge, skills and understanding through their study of mathematics; and/or
- equip students with a range of mathematical skills and experiences as a preparation for entry to the workforce at a foundation level, or as a prerequisite for further specialised post-compulsory education and training.

Generally there are mathematics courses across Australia that can be categorised as

> *Courses designed to consolidate and develop the foundation and numeracy skills of students with respect to the practical application of mathematics in their lives, in their community, or related to employment or other areas of study. These often have a thematic basis for course implementation.*
>
> *Courses designed to provide a general mathematical background for students proceeding to employment or further study with a numerical emphasis.*

There is a commonality in approach currently across the jurisdictions in the development of these courses and their focus on applying the study of mathematics to the analysis of everyday work and life problems. They generally promote opportunities for the development of mathematics that enables students to view problems mathematically and develop greater confidence in deriving solutions through the application of mathematical strategies. Consistent themes that underpin these courses that aim to improve the match between school and workplace mathematics include:

- promoting an understanding of mathematics in a range of relevant work contexts;
- understanding the role of mathematics in contemporary technological society;
- acquiring practical work skills in mathematics in a range of contexts;
- gaining the mathematical knowledge and skills required for the particular pathway that the student has chosen;
- improving students' 'preparedness for entry to work, apprenticeships, traineeships'; and
- providing the skills and knowledge required to analyse and apply effective mathematical practices to meet the needs of workplace contexts by:
  - organising mathematical ideas and representing them in a number of ways such as, diagrams and maps, graphs, tables, and texts relevant to the workplace;
  - presenting mathematical findings orally and in writing; and
  - making informed decisions using mathematics information and data.

There is now a need to examine the relationship between the documented curriculum, classroom tasks for learning of mathematics and how the Australian Curriculum: Mathematics can be used to promote opportunities to build school-based approaches that better match classroom learning with workplace needs. The most appropriate place to accommodate teaching approaches that are not just about knowing fundamental mathematics, but also about knowing which mathematics to use and being able to construct appropriate models and interpret and communicate the results is within the Proficiency strands of the Australian Curriculum: Mathematics.

The Proficiency strands describe how students interact with the content i.e. they describe how the mathematical content strands are enacted through key mathematical behaviours. They provide the language to incorporate the developmental aspects of the learning of mathematics that go beyond the routine numeracy-based procedures and use 'judgement' or 'problem-solving' skills and experience with multi-step, data-dependent operations in complex settings.
The four proficiency strands, as described in the *Shape of the Australian Curriculum: Mathematics, May 2009 - ACARA*, are;

- *Understanding*, which includes building robust knowledge of adaptable and transferable mathematical concepts, the making of connections between related concepts, the confidence to use the familiar to develop new ideas, and the 'why' as well as the 'how' of mathematics.
- *Fluency,* which includes skill in choosing appropriate procedures, carrying out procedures flexibly, accurately, efficiently and appropriately, and recalling factual knowledge and concepts readily.
- *Problem solving*, which includes the ability to make choices, interpret, formulate, model and investigate problem situations, and communicate solutions effectively.
- *Reasoning,* this includes the capacity for logical thought and actions, such as analysing, proving, evaluating, explaining, inferring, justifying, and generalising.

c. Implications for the teaching of Mathematical Skills and Technology

A key theme emerging from the study is that the increase in technology has changed the mathematical practices in which people in the workplace are required to engage. Much mathematics carried out in the workplace is now carried out using technology with spreadsheet usage being particularly prevalent in the worksites involved in this project. Workers are now required to undertake higher-level cognitive tasks such as interpreting the meaning of the computer generated results of calculations and understand the significance of the numerical output as calculations move from manuals and charts to spreadsheets, computers screens and calculators. In general, the observation was that technological advances appear to have increased, not decreased, the mathematical demands of many workers.

The implication for teaching and learning has already been noted in the development of the *Australian Curriculum: Mathematics* -

> *An important consideration in the structuring of the curriculum is to embed digital technologies so that they are not seen as optional tools. Digital technologies allow new approaches to explaining and presenting mathematics, as well as assisting in connecting representations and thus deepening understanding. The continuing evolution of digital technologies has progressively changed the work of mathematicians and school mathematics (consider the use of logarithm tables and the slide rule), and the curriculum must continue to adapt.*
>
> *Digital technologies are now more powerful, accessible and pervasive e.g. modern mathematical technologies (hand-held devices or computer software) support numerical, statistical, graphical, symbolic, geometric and text functionalities. These may be used separately or in combination. Thus, a student could readily explore various aspects of the behaviour of a function or relation numerically, graphically, geometrically and algebraically using such technologies. These approaches allow greater attention to meaning, transfer,*

connections and applications. Digital technologies can make previously inaccessible mathematics accessible, and enhance the potential for teachers to make mathematics interesting to more students, including the use of realistic data and examples.

There is an inter-dependency between mathematical skills and the use of technology in the workplace that is not always reflected in teaching practice. To close the gap between school mathematics and the use of mathematics in the workplace technological tools, such as computer algebra systems, interactive geometry software, applets, spreadsheets, and interactive presentation devices need to become vital components of mathematics education. Students can use these tools to support and extend mathematical reasoning and sense making, gain access to mathematical content and problem-solving contexts, for computation, construction and representation as they try to find solutions to problems and contribute to mathematical reflection, problem identification and decision making.

The use of technology cannot replace conceptual understanding, computational ability, or problem-solving skills. Teachers must be knowledgeable decision-makers in determining when and how their students can use technology most effectively. Programs in teacher education and professional development will need to continually update practitioners' knowledge of technology and its classroom applications so they can take advantage of technology-rich environments and the integration of technology in day-to-day instruction. Technological tools, including those used specifically for teaching and learning mathematics, should not only complement mathematics teaching and learning but also prepare students for their future lives, which technology will influence every day.

d. A Framework for supporting critical thinking, analysing situations and solving problems

As reported earlier the use of workplace mathematics often goes beyond the procedural use of mathematical skills to their application in situations that require blending skills. The competent application of mathematical concepts in complex workplace contexts requires more than the use of fundamental mathematical skills and understandings. Rather, it requires a set of blended skills and capabilities that includes a mixture of:

- understanding the mathematical concepts, procedures and skills that workers need to know;
- understanding the kinds of practical tasks they need to perform; and
- understanding the processes they should be able to use in applying mathematics – recognising how mathematics might help, choosing and adapting the mathematics needed, making decisions about the accuracy required and reviewing the methods used in the context.

This has implications for the content and structure of both education and training. In addition to the mathematical content and skills, which will continue to be a key part of the total skills required of today's workforce, there is a set of cognitive skills that people require to deal with more complex situations. These are described as *executive functions* – a set of mental processes that can help connect past experience with present action. The competent use of mathematics in the workplace is not just about being able to do fundamental mathematics, but about knowing which mathematics to use and being able to construct appropriate models and interpret and communicate the results. Workers use *executive functions* to perform activities such as planning, organising, strategising, paying attention to and remembering details, and managing time and space. The three components of the *executive functions* are generally taken to include:

- Resisting impulses – stopping to allow time to think before taking action;
- Effective use of working memory – bearing a number of things in mind while thinking about how to do something; and
- Cognitive flexibility – capacity to think about a problem in different ways.

For mathematical contexts in the workplace, these executive functions will be integral to things like - the worker knowing what mathematics from their 'toolkit' will be useful in the context; applying that mathematics, understanding the effects of practical constraints, recognising an unreasonable result, checking and correcting their calculations and solutions; relating the mathematics to others; and enhancing the ability to think and problem-solve rather than working with isolated tasks and problems. Executive functions are not only skills that should be used in combination with the mathematical content but also as the basis for strategies that all teachers should consider using to enhance the learning capacity of their students. Students need to develop the ability to explore, to make and test conjectures, to reason logically, and to use a variety of mathematical methods to solve problems. Indeed most of the processes identified as part of '*mathematical modelling*'.

Understanding the impact of *executive functioning skills* on mathematics is very important for teachers. Rather than viewing difficulties with mathematics as being the result of simply not understanding particular mathematical operations it may be that issues such as poor working memory, organization, and planning skills are having an impact on mathematical capability. As a result, it is helpful to consider the role of these *executive functions* in ensuring mathematical competence in the workplace**.** This will require insight into the relationship between thinking skills, executive functions, and mathematics concepts, procedures and skills.

The following table is a tentative guide to this connection.

Resisting Impulses – *stopping to allow time to think before any action;*	Sustaining attention to the task, not getting distracted in the middle of completing a problem, setting goals and working to meet them. Thinking ahead about what kind of problem this is, and what options you have for solving it, planning the steps you will use to solve the problem. Organizing the work so that it is clear, organizing images/notes on page, organising information and distilling the mathematical information in written text Being able to sustain attention long enough to grasp a difficult concept without giving up. Not rushing to get a solution problem just to finish, but really thinking it through to help ensure confidence in the solution.
Working Memory – *bearing a number of things in mind while thinking about how to do something;*	Keeping different steps to solving a problem in mind, recalling which formulas to use to solve which problems and keeping parts of a multistep problem in mind. Keeping all of the different components to a problem in mind while solving it, thinking about previous steps while doing the current one, retrieving previously learned information to apply it to the current problem or task and applying mathematical rules. Recalling prior knowledge and relating it to new ideas and situations.
Cognitive Flexibility – *capacity to think about a problem in different ways*	Thinking about whether or not their reasoning makes sense as they work to solve a problem. Thinking about the steps used to solve previous problems and using that to self-correct and check. Shifting between different representations written in sentences, symbols and graphics and being able to switch between representations when needed. Being able to explain and communicate their reasoning in writing or to others, being able to think about and explain the steps used to solve different kinds of problems, being able to explain the reasoning behind completing a mathematical problem in a certain way

The suggested framework acknowledges that alongside the need to know how to perform 'core' mathematical procedures and techniques the executive functions will help meet the requirements of a worker to use these procedures and techniques in sophisticated workplace activities. The marrying of mathematical content and executive functions can be a key determinant of a student's success in applying mathematical content in more work complex situations. This has implications for the content and structure of mathematics education as it describes more than a set of simple and disconnected skills and goes well beyond a command of basic mathematics and numeracy.

Strategies to improve the integration of mathematical skills and executive functions need to be considered in teaching approaches with a focus on improving the understanding of how the relationship between thinking skills, executive functions and mathematics concepts, procedures and skills can enhance the teaching and learning of mathematics and of mathematical use and competence in the workplace.

e. Current Resources and Guidance

i Purpose and Background

A key component of the Identifying and Supporting Quantitative Skills of 21st Century Workers project has been to identify and categorise a range of 'workplace mathematics' teaching and learning resources. The aim is for this work to be available to inform teachers of mathematics in and for the workplace. The Project identified a sample of resources that can be utilised to bridge the gap between the applied mathematics skills required in the workplace and how the concepts taught in schools. The analysis has focussed on identifying mathematical processes and instructional design in teaching and learning resources that:

- will enable students to choose what mathematics to use in order to deal with familiar and unfamiliar situations; and
- provide the opportunity for teachers to appreciate how different workplace contexts and issues change the way mathematics is used and how the results are presented.

The Process for identifying Resources

The analysis was undertaken with the understanding that the use of mathematics in the workplace is highly contextualised and integrated with work functions. As outlined earlier mathematical skills are used in a very particular or contextualised manner in each workplace and, unlike school mathematics practices, workplace tasks are usually performed using idiosyncratic methods developed within the workplace and couched in language that is often particular to both the task and industry or workplace.

The Project sought out indications of resources through networks (AAMT Affiliates; officers of education authorities; publishers; internet; general networks of teachers and schools) that can develop self-confidence in the use of existing mathematical tools and their application in the world of work. The criteria for the selection of resources were that they:

- set the mathematical skills in real or simulated workplace based contexts;
- support teaching practices for the acquisition of mathematical skills involving basic number operations, problem solving strategies, formula, measurement, scale, ratio, time, information communication technology and relate these skills to the workplace situation;
- present different types of mathematical skills found in the workplace and presented some specific job task examples practitioners may encounter in the workplace in different industries; and
- look at workplace tasks which involve a combination of different types of numeracy/mathematical skills.

Resource 'evaluation guide'

All in all, there are substantial numbers of teaching and learning resources both in Australia and overseas that provide materials that are well-adapted to the needs of students and make extensive use of real-world workplace applications. Hence the question in the first instance is not about developing more resources, but to categorise and understand the use of currently available resources for specific purposes in teaching and in teacher development.

Broadly the resources identified were classified into three different categories.

1. *Resources that provide specific examples of the use of mathematics within a workplace context*
   These resources can be used to respond to employers' observations that there are many mathematical skills that are used 'again and again' in the routines used in the workplace. These skills include ratio and proportion; reading and interpreting graphs; and evaluation and approximation. School learners need time to become confident in using these skills and it would assist learners to transfer the skills if they were given an opportunity to explore their applications in specific occupations that are interesting and relevant to them.

2. *Resources to help teachers understanding the use of mathematical skills in the workplace*
   This is in response to the study's observation that some of the mathematics present implicitly in jobs and tasks is not obviously mathematical and cannot be 'lifted out' for teaching purposes without losing much of what makes it complex and relevant. Given that mathematics looks different in the workplace these resources have been identified to meet the needs of mathematics teachers in contextualising mathematics and numeracy skills to the world of work.

3. *Resources that provide learning opportunities and contextualized experiences.*
   These resources have been identified in response to the evidence that the application of mathematics in the workplace is much more than a set of simple and disconnected skills and goes well beyond a command of number or basic mathematical content. Workers tend to use skills beyond the routine numeracy-based procedures. These resources respond to employer observations that maths skills cannot be taught as discretely defined skills or concepts, but need the experiential process usually associated with the workplace. These resources were therefore identified because they go beyond teaching mathematical techniques alone, but also involve teaching the reasoning, the understanding, the flexibility, and the perseverance in contextualised situations. They generally focus on the processes students should be able to use in applying mathematics in the workplace and provide a link to the executive functions.

Teachers wanting to use resources within these broad categories should consider their purpose as summarised in the next section.

ii Guidance for identifying and using resources that provide specific examples of the use of mathematics within a workplace context

Resources reviewed within this category can provide experiences as a preparation for entry to the workforce at a foundation level or as a prerequisite for further specialised post-compulsory training. They will assist teachers to increase entry points (in terms of ability level) from which students can pass trade courses - using up-to-date workplace mathematics. They can be used to practice mathematics skills that are used '*again and again in routine processes' in* the workplace.
They can be primarily used to assist and support teachers who have students considering an apprenticeship, further learning (such as TAFE and who may be currently undertaking a VET course) or who want to work.

These resources incorporate approaches for the development of mathematical skills in targeted industry areas by equipping students with the underpinning mathematics knowledge and skills that are linked to specific jobs. These resources generally combine practical, real-world scenarios and terminology relevant to a chosen industry/occupation

In summary they can support for teaching that provides students with the mathematical skills they need to:

- confidently pursue a career within an industry area;
- improve their preparedness for entry to work, apprenticeships, traineeships in that industry area; and
- organise mathematical ideas and represent them in a number of ways such as, diagrams and maps, graphs, tables, and texts in a specific workplace context.

Attachment 1 provides a description of a sample of these resources

iii Guidance for identifying and using Resources - to enhance teachers understanding of the use of Mathematical Skills in the Workplace

The resources identified in this category are generally drawn from a workplace or vocational environment and can support teachers to improve their understanding of mathematical contexts in the workplace and in contextualising mathematics and numeracy skills to the world of work.

Rather than furthering mathematical knowledge, these resources are about developing self-confidence in the use of existing mathematical tools and their application in the workplace. They are industry specific and generally:

- describe how mathematics/numeracy is conceptualised and used in workplace settings as opposed to the classroom;
- combine practical, workplace scenarios and terminology specifically relevant to an industry area; and
- describe how the necessary underpinning mathematical knowledge and skills, and mathematical concepts are linked to specific jobs.

The resources, although generally developed for use by VET trainers and Assessors, can be used by mathematics teachers to get an understanding of specific workplace numeracy/mathematics facets, including:

- the use of formal and informal mathematical language, symbolic and diagrammatical representations and conventions of mathematics in specific workplaces;
- identifying mathematical information and meaning in job activities and tasks;
- solving a range of numeracy problems within specific workplace contexts; and
- facilitating the learning of numeracy/mathematics skills in specific workplace contexts.

Attachment 2 provides a description of a sample of these resources

iv Guidance for identifying and using Resources - that provide learning opportunities and contextualized experiences

These resources can be used for instructional design that focus on the processes students should be able to use in applying mathematics – given the understanding that much of the workplace mathematics involves the application of a range of mathematics and numeracy skills in a way that also incorporates critical thinking, analysis and problem-solving skills. Examples from outside the workplace context tend to perpetuate teaching approaches inappropriate in the workplace.

The resources will generally incorporate material and approaches from specific fields into course content, and employ projects, simulations, and other experiences that enable students to learn by doing. They promote teaching from a contextual and task based or investigative point of view with the use of existing mathematical tools and practices, and their application in a workplace context. They generally promote learning tasks that require higher levels of mathematical thinking and reasoning and are related to the use of instructional tasks that engage students in the 'doing of mathematics' or the use of procedures with understanding and meaning. In addition, these resources promote those tasks that encourage the use of multiple solution strategies, multiple representations, and explanations as opposed to those tasks which tend to be both set up and implemented in a procedural manner and that require a single solution strategy, single representation and little or no mathematical communication.

These types of resources should be used where teachers want to incorporate instructional approaches where:

- mathematical concepts are presented in workplace situations and experiences that are familiar to the student;
- concepts in student exercises and examples are presented in the context of use in the workplace;
- new concepts are presented in the context of what the student already knows;
- examples and student exercises include many real, believable problem-solving situations that students can recognise as being important to their current or possible future lives;
- examples and student exercises cultivate an attitude that says "I need to learn this";
- students gather and analyse their own data as they are guided in discovery of the important concepts;
- students are expected to gather and analyse their own data for enrichment and extension;
- lessons and activities encourage the student to apply concepts and information in useful contexts, projecting the student into imagined futures (e.g. possible careers) and unfamiliar locations (e.g. workplaces);
- students are expected to participate regularly in interactive groups where sharing, communicating and responding to the important concepts and decision-making occur; and
- lessons and activities improve students' reading and other communication skills in addition to developing their mathematical reasoning and achievement.

Attachment 3 provides a description of a sample of these resources

5. Recommendations and Actions

The following recommendations identify further work to be undertaken in four key priority areas, to support the development of the mathematical awareness, knowledge and attitudes in young people required by workers now and into the future.

- Generating greater national awareness and understanding of how mathematical skills/processes/techniques are conceptualised and used in workplace settings.
- School Based Research and Development of strategies for mathematics teaching to better reflect the real expectations of contemporary workplaces.
- Curriculum Development – the development of clear advice on how to support the development and transfer of mathematical skills to the workplace.
- A strategy for supporting change in schools.
- A strategy for supporting mathematical capability and numeracy in the workplace

Generating greater national awareness and understanding of how mathematical skills/processes/techniques are conceptualised and used in workplace settings

1. AAMT, Ai Group and OCS disseminate the findings from the Identifying and Supporting Quantitative Skills of 21st Century Workers project by preparing and distributing short summaries that inform and engage teachers, business, education authorities and relevant policy groups at the national, state and territory and local levels.

2. AAMT, Ai Group and OCS collaboratively plan and implement a series of Roundtables that involve mathematics teachers, AAMT state and territory Affiliates, mathematics educators and targeted Industry Skills Councils in strategic discussions on the scale and scope of the national challenges facing the application and transfer of mathematical skills in the workplace. The outcome of the Roundtables should be a synthesis of the discussions and identification of useful directions for uptake of the findings by both the Industry and education sectors.

School Based Research and Development of strategies for mathematics teaching to better reflect the real expectations of contemporary workplace

3. The AAMT, Ai Group and OCS identify examples from the Case Study Research that elaborate or exemplify mathematical principles and connections in the workplace. These examples will allow teachers to situate mathematics within contextualised practical workplace problems in their teaching and learning programs.

4. The AAMT seek support to undertake further collaborative research into the knowledge and pedagogical approaches required by teachers to better match the teaching of mathematics in school with the application of workplace mathematics in diverse teaching settings. This should include the development of a set of guidelines for the design of classroom activities that encourage and support the teaching and learning of mathematics within real world contexts including the use workplace specific open-ended mathematical tasks for students.

5. The AAMT seek support to further consider and develop the connections between mathematical skills and executive functions as a key determinant of a student's success in transferring mathematics learnt at school to complex work and out of school situations. The research will provide improved understanding of how the relationship between thinking skills, executive functions, and mathematics concepts, procedures and skills can enhance the teaching and learning of mathematics and of mathematical use and competence in the workplace

Curriculum Development – the development of clear advice on how to support the development and transfer of mathematical skills to the workplace

6. The AAMT work with ACARA and Education Services Australia (ESA) to examine the relationship between the documented curriculum, classroom tasks for the learning of mathematics and the *Proficiency strands* and how they can be used to promote opportunities to build school-based interventions/approaches that better match classroom learning with workplace needs.

7. The AAMT work with ACARA, the Australian Council for Computers in Education and Industry to identify opportunities to embed work-related technologies – particularly spreadsheets and computer generated graphics – in the curriculum and teaching. This work will support and extend students' mathematical reasoning and sense making; provide access to mathematical content and problem-solving contexts; provide work relevant tools for computation, construction, and representation as students explore mathematical and interdisciplinary problems; and contribute to mathematical reflection, problem identification, and decision-making.

A strategy for supporting change in schools

8. The AAMT and Ai Group seek support to engage local partnerships between schools and businesses to identify and co-design practical demonstrations and 'teaching' activities that link the teaching of mathematics directly to workplace contexts. This work will be informed by the findings and materials from this project.

9. The AAMT and its state and territory Affiliates to develop and implement a focused professional development strategy, and support materials, for mathematics teachers to enhance their knowledge around the distinctions between the development and use of *mathematics* in the school as opposed to the world outside the classroom, specifically including the workplace.

A strategy for supporting mathematical capability and numeracy in the workplace

10. Given the project findings about the use of mathematics in the workplace the Ai Group seek support to work with other organisations to further investigate the development of numeracy skills in the workplace as new workers enter the workforce.

Attachment 1

Resources that provide specific examples of the use of mathematics within a workplace context

These resources will assist teachers to increase entry points (in terms of ability level) from which students can pass trade courses - using up-to-date workplace mathematics and practicemaths. They aim to equip students with a range of maths skills and experiences as a preparation for entry to the workforce at a foundation level or as a prerequisite for further specialised post-compulsory training. They will assist and support teachers who are teaching students considering an apprenticeship, further Learning (such as TAFE and who may be currently undertaking a VET course) or who want to work.

They can be used to practice mathematics skills that are used '*again and again in routine processes in the workplace'.* These resources are primarily aimed at supporting school learners to become confident in using these skills by their applications in occupations that might be relevant to them. These skills generally include ratio and proportion; reading and interpreting graphs; and evaluation and approximation.

Examples of resources that meet these needs are described in the table below.

RESOURCE	DESCRIPTION
INDUSTRY FOCUSSED APTITUDE TESTS ***Automotive Aptitude Test*** ***Construction Aptitude Test*** ***Electrical Aptitude Test*** ***Engineering Aptitude Test*** ***Hospitality Aptitude Test*** ***Plumbing Aptitude Test*** **http://www.gtasa.com.au/**	These resources are intended to prepare young people who may be required to sit an aptitude test as part of an interview and assessment process for a job vacancy, such as an apprenticeship. They can be used: - To provide individual people the opportunity to practice and hone their skills before sitting an actual aptitude test. - by Teachers for individuals or in a class setting to provide general guidance to students on what they may expect during the interview process if they intend commencing a career as an apprentice - by mathematics Teachers as a guide to Industry mathematics requirements at the entry point of a particular apprenticeship career path - to provide general guidance on the level of study involved in undertaking an entry-level qualification in this industry; - by mathematics teachers as a guide to industry math requirements at the entry point of this particular Australian Apprenticeship career path; - by teachers as a guide to industry math requirements at the entry point of this particular Australian Apprenticeship career path The Questions focus on literacy, numeracy, comprehension, mechanical and problem solving questions contextualised to the particular industry. The mathematics skills required to complete the questions contained within this document are equivalent to mathematics at the Year 10 level.
CENCAGE LEARNING PRODUCTS ***Maths and Literacy for Trades (A range of Industry Areas)***	These resources have been specifically tailored to prepare students for sitting apprenticeships or VET/TAFE admission tests and for giving students the basic skills they need for a career in trade. The content in these resources is aimed at the level that is needed for a student to have the best possibility of improving their maths skills specifically for trades. They aim to bridge the gap between what has been learnt in previous years and what needs to be remembered and re-learnt for use in trades. Students can use the workbooks to prepare for an apprenticeship entry assessment or to assist with basic numeracy at the VET/TAFE level. Coupled with interactive CDs they can be used to improve a student's understanding of basic Maths concepts that can be applied to the trades. Commonly used trade terms are introduced so that students get a basic understanding of terminology that they will encounter in the workplace environment.
bocklayer.com builders software online.	**Web Apps for Builders, Contractors, Tradespeople** that include simple applications for various geometric calculations online-calculation tools for concrete blocks, stairs, and other construction design tasks

Attachment 2

Resources to help teachers understanding the use of Mathematical Skills in the Workplace

These resources have identified because they will allow teachers to examine different types of numeracy/mathematics skills found in the workplace. They present specific job task examples that their learners may encounter in the workplace in different industries. There are a number of workplace numeracy resources developed under the umbrella of the *WELL program* - to promote cross industry sharing and collaboration on issues relating to foundation skills, including numeracy practice in workplace training and assessment.

A database link to the Industry Skills Councils' (ISCs) website/resource pages (which can be found below) provides a repository of various resources developed as part of the suite of WELL funded professional development resources support the development of practitioners. They can be used to raise awareness and provide information, case studies and tools to enhance knowledge and understanding of the range of numeracy issues and support needs of learners in the workplace. The resources can support teachers to gain a comprehensive understanding of numeracy and provide specific support when needed. They focus on methods and processes for analysing the mathematical/numeracy requirements of learners and look at the different types of numeracy skills found in different workplace contexts.

The resources will help teachers to identify numeracy behaviour in the workplace i.e. – how to - *manage a situation or solve a problem in specific workplace contexts; respond to information about mathematical ideas that may be represented in a range of ways; activate of a range of enabling knowledge, factors, and processes.*

By using these resources teachers can get an understanding of;

> **How to respond in the workplace-** identifying or locating or acting upon - *order/sort; count; estimate; compute; measure; model;* interpreting ; communicating about **Information about mathematical ideas in the workplace -** quantity and number; dimension and shape; pattern and relationships; data and chance; change **that is represented in a range of ways -** objects and pictures; numbers and symbols; formulas; diagrams and maps; graphs; tables texts **and requires activation of a range of enabling knowledge, behaviours, and processes -** mathematical knowledge and understanding; mathematical problem-solving skills

RESOURCE	DESCRIPTION
AUTO SKILLS AUSTRALIA	**Use numbers in an Automotive Workplace** - Online (blended) learning programs to support practioners on Numeracy Training and Assessment in the workplace. Videos cover - Why is Numeracy so important - What are Numeracy skills and what do they look like in the workplace
COMMUNITY SERVICES & HEALTH ISC	**Foundation Skills - ACSF Skills Check -** the kit has been designed for use by a wide range of workplaces, with particular relevance to the Community Services and Health Industry. It is a tool to help workplaces quickly and easily assess the levels of their employees' core skills (including Numeracy) against the Australian Core Skills Framework (ACSF). It provides benchmarks for performance needed in a particular context, such as the workplace. **WELL Training Kit –** is suited for supporting core skills (including Numeracy) in the workplace. This comprehensive and easy-to-use Workplace English Language and Literacy (WELL) resource kit is mapped up to the Level 3 against the Australian Core Skills Framework. It is contextualised to the Community Services and Health industry
CONSTRUCTION AND PROPERTY SERVICES ISC	**Developing Trades Math Worksheets - A** Handbook for Construction Trades Instructors. This guide for trainers working with learners in the construction trades provides guidance on developing math's worksheets using the Essentials Skills required by construction apprentices. It provides trainers with a very structured approach but relies on apprentices having base knowledge of key facts such as formulas. **Trash Talk -** Can be used to address numeracy in the Waste Management. The guide has four parts: - Understanding the Australian Core Skills Framework (ACSF) covers basic Numeracy terminology, - Understanding the Numeracy skills to help practioners identify the Numeracy skills in *Waste Management* training - Preparing learning activities has case studies and sample activities for practioners - Resources include publications, websites, and numeracy skills checklist that practioners can use to record learners' progress.
EE-OZ TRAINING STANDARDS (INDUSTRY SKILLS COUNCIL) **http://www.ee-oz.com.au/**	This online resource is based on the numeracy demands encountered when undertaking an Australian Apprenticeship in Certificate III in Electro technology in which algebraic skills are required - especially the Essential Knowledge and Skills encountered during off-the-job training. The online resource demonstrates the **Electro technology applications** of algebra

GOVERNMENT SKILLS AUSTRALIA	**Meeting the Foundation Skills Demands of Training and Work -** This professional development resource has been developed to raise awareness of foundation skills (including Numeracy) issues amongst workers. The accompanying short videos aim to build awareness of the numeracy or 'core' skill demands of tasks embedded in work roles within the government and community safety industries. The guide aims to provide practioners with information about how to identify the Numeracy skills embedded in both work and training contexts. They are easily disguised in a variety of tasks and roles so often go unnoticed. This guide offers some strategies to develop an understanding of what Numeracy skills are, where they can be found and how they can be addressed in practical terms.
INNOVATION AND BUSINESS SKILLS AUSTRALIA	Building strong foundations – online resource to support implementation of the Foundation Skills, including examples, advice and video series The resource includes tips, templates and examples practioners including video segments and professional development advice, answers to frequently asked questions links to related resources
MANUFACTURING SKILLS AUSTRALIA	**Putting the jigsaw together** –numeracy tool kits for practioners including practical strategies to assist apprentices to develop their numeracy skills. Tool kits include: numeracy indicator tools, a comprehensive trainers' guide and a series of tools that target numeracy skill areas. **Making the connections** – Manufacturing Skills Australia professional development resource for building the capability of practioners to address numeracy embedded in vocational training. The resource is presented as a professional development workshop
SERVICE SKILLS AUSTRALIA	**Taking the lead** – Service Skills Australia online resource for information and advice on numeracy. A one-stop shop for information and advice on developing core numeracy (LLN) skills in the service industries including the sport, fitness and recreation; tourism, travel and hospitality and wholesale, retail and personal services
SKILLS DMC	**Diggin' in!** – resource developed by to help practioners address the numeracy skills required within the Resources and Infrastructure Industry

The WELL program also has developed a range of professional development resources to support the development and recognition of numeracy training skills and knowledge.

Examples of these resources that meet are described in the table below.

RESOURCE	DESCRIPTION
AUSTRALIAN CORE SKILLS FRAMEWORK (ACSF) TOOLS	Precision Consultancy have completed a bank of language, literacy and numeracy assessment tasks written against the Australian Core Skills Framework (ACSF), funded by the WELL program. The tools cover a range of industry areas and have been trialed and validated by industry experts. They are freely available at www.precisionconsultancy.com.au/acs_framework . The site includes a user guide that explains how the tasks can be used. Trainers and assessors who have used them have found them very useful to determine and understand learners LLN levels, which provides a basis for addressing LLN needs.
NCVER Research	NCVER has released a range of Numeracy Reports aimed at generating and sharing ideas within the adult numeracy. They can get you thinking about how you can apply Numeracy in the workplace. - Berghella, Tina & Molenaar, John (2013). *Seeking the N in LLN*. Adelaide, South Australia: National Centre for Vocational Education Research (NCVER). - Gleeson, Lynne (2005). *Economic returns to education and training for adults with low numeracy skills*. Adelaide, South Australia: National Centre for Vocational Education Research (NCVER). - Marr, B., & Hagston, J. (2007). *Thinking beyond numbers: Learning numeracy for the future workplace*. Adelaide, South Australia: National Centre for Vocational Education Research (NCVER). - Mlcek, Susan, FitzSimons, Gail, Wright, Claire and Hull, Oksana (2005) *Learning numeracy on the job: A case study of chemical handling and spraying*. Adelaide, South Australia: National Centre for Vocational Education Research (NCVER)

WHAT WORKS FOR LLN – **http://www.ideasthatwork.com.au/what-works-for-lln**	Online library of FREE language, literacy and numeracy (LLN) training and professional development videos. These videos contain practical LLN tips and good practice examples to help build vocational trainers and assessors' capacity to support learners with LLN needs. The What Works videos are grouped into three series: Introduction to LLN video series - These videos can be used as professional development for practitioners and cover such things as what LLN skills are, why they are important, how to identify learners' LLN skills, the LLN requirements of the job and when is specialist LLN support needed. Practical LLN tips for trainers and assessors' video series - These videos present more in depth information and good practice examples to help build vocational trainers and assessor's capacity to support learners with LLN needs. This includes tips for VET and LLN practitioners working together, accessing LLN support, designing and customising learning and assessment materials and practical examples of how to develop learners' LLN core skills. Introduction to workplace LLN video series - These videos can be used to help practioners understand what LLN skills are. LLN skills help people do their jobs and are often so much a part of their work that they are not thought of as separate skills. It gives an overview of what LLN skills look like in various workplaces.
SUPPORT MATERIAL FOR TAE70110 AND TAE80110	This is a professional development resource to support the development and recognition of numeracy training skills and knowledge of Workplace English Language and Literacy (WELL) Practitioners consistent with the requirements of the Vocational Graduate Certificate in Adult Language, Literacy and Numeracy Practice. This resource can be used as resource material to support the following competencies from the TAE70110 Vocational Graduate Certificate in Adult Language, Literacy and Numeracy Practice: - TAELLN702A Analyse and apply adult numeracy teaching practices - TAELLN704A Implement and evaluate delivery of adult language, literacy and numeracy skills It can support practioners in their numeracy teaching skills and their understanding of typical workplace numeracy activities. This resource can meet the professional developmental needs of Practitioners who: - Need to improve their basic numeracy skills to support WELL training delivery - Have basic numeracy skills but need to update in respect to changing technology and numeracy practices - Have basic numeracy skills but need to contextualise to the world of work

Attachment 3

Resources that provide learning opportunities and contextualized experiences

These resources have been selected on their bases to incorporate mathematical skills instruction in the world of work generally and through student study of mathematics in work-related contexts. They incorporate instructional design that focuses on the selection and application of appropriate mathematical techniques and problem-solving strategies and generally include activities to promote the transfer of mathematical skills i.e. using mathematical skills and knowledge—existing or newly acquired—in a new context or work situation.

Learning opportunities have been contextualised and incorporate material from specific fields into course content, and employ projects, simulations, and other experiences to enable students to learn by doing. They generally promote learning tasks that require higher levels of mathematical thinking and reasoning and are related to the use of instructional tasks that engaged students in the “doing of mathematics” or the use of procedures with connections to meaning. In addition these resources promote those tasks that encourage the use of multiple solution strategies, multiple representations, and explanations as opposed to those tasks which tend to be both set up and implemented in a procedural manner and that require a single solution strategy, single representations, and little or no mathematical communication.

They promote teaching from a contextual and task based or investigative point of view with the use of existing mathematical tools and practices, and their application in a workplace context.

RESOURCE	DESCRIPTION
CORD Mathematics **Contextual Mathematics Materials** CORD Communications serves the educational market by providing products and services designed to improve student achievement by integrating active learning into academic and career and technology classrooms	
CORD BRIDGES TO ALGEBRA AND GEOMETRY: *MATHEMATICS IN CONTEXT, THIRD EDITION* CORD Bridges to Algebra and Geometry is published by CORD Communications www.cordcommunications.com	This resource bridges the gap between abstract mathematical concepts and real-world applications. It integrates algebra and geometry while providing ongoing opportunities in critical thinking. CORD Bridges to Algebra and Geometry employs an interactive, workplace-centered approach to teaching the foundations of algebra and geometry. The program features hands-on math labs and cooperative group activities, giving students the opportunity to experience mathematical concepts. It offers connections and applications to everyday life and emphasises the use of math in the workplace.
CORD ALGEBRA 1: LEARNING IN CONTEXT; *THIRD EDITION* CORD Algebra 1 is published by CORD Communications, www.cordcommunications.com.	Employs an interactive, workplace-centred approach to teaching algebra concepts. CORD Algebra 1 teaches abstract concepts through concrete experiences. It can be used for various course offerings - algebra 1 over two years, block scheduling, and one-year algebra classes - because of its multiple packaging formats: single text, two-volumes, or chapter modules. CORD Algebra 1 integrates topics such as trigonometry, statistics, and probability. As topics are introduced and developed, students experience concepts through real-world applications. Video segments set the stage for each chapter by demonstrating how algebra is used in today's workplace. Hands-on math labs give students the opportunity to experience mathematical concepts. It emphasises the use of math in the workplace through multi-step exercises covering five occupational areas.
CORD ALGEBRA 2: LEARNING IN CONTEXT CORD Algebra 2 is published by CORD Communications, www.cordcommunications.com	Takes math from abstract concepts to concrete applications to which students can better relate. Students will see math at work in five key employment areas: Business and Marketing, Health Occupations, Industrial Technology, Family and Consumer Science, and Agriculture/Agribusiness. Course materials available are a hard cover student text, instructor's edition, instructor's resource book, laboratory data sheets, and assessment software.
CORD GEOMETRY: LEARNING IN CONTEXT, *THIRD EDITION* CORD Geometry is published by CORD Communications, www.cordcommunications.com.	An innovative program that uses real-world, workplace applications and lab activities as the platform for teaching geometry. The course materials engage contextual learners in cooperative teams, allowing them to experience concepts while making math practical and relevant. CORD Geometry bridges the gap between abstract geometrical concepts and applications to the real world. It integrates geometry with ideas from algebra, probability, statistics, discrete mathematics, and trigonometry. It presents proof in paragraph, two-column, flow chart, indirect, coordinate, and transformational formats. Hands-on math labs and class activities allow students to experience mathematical concepts. Ongoing opportunities are provided through lesson development and exercises to improve critical thinking skills. CORD Geometry offers connections and applications to everyday life and emphasizes the use of math in the workplace through multi-step exercises covering five occupational areas.

CORD APPLIED MATHEMATICS: CORD Applied Mathematics is published by CORD Communications, www.cordcommunications.com.	A competency-based curriculum that emphasizes problem solving, decision making, and hands-on learning. CORD Applied Mathematics teaches algebra and geometry concepts in the context of occupational settings. It acknowledges the diversity of learning styles in today's classroom and enables teachers to support all learners. The course materials engage students in cooperative teams, allowing them to participate in laboratory-centered, hands-on activities that make mathematics concepts practical and relevant.
THE RITEMATHS PROJECT	RITEMATHS is a project of the University of Melbourne and the University of Ballarat with seven industry partners. It aims to enhance mathematics achievement and engagement by using technology to support real problem solving and lessons of high cognitive demand. The program uses real problems and information technology to enhance students' engagement with and achievement in mathematics. The broad aim of this project was to discover effective ways to use technology to stimulate higher-order thinking in mathematics classrooms, in the context of using real world problems. There are three main research areas: - *Context Theme.* Can we use new technology to overcome some of the obstacles inherent in using real-world problems? Data logging and multimedia can bring a virtual world into the classroom for analysis, and the maths analysis tools can provide easy calculation and graphing. - *Algebra theme.* How can CAS enhance what can be done with real problem solving in ordinary school settings? Can learning algebra through real world problem situations provide more meaning for algebraic concepts? - *Affordances theme.* How do various features of technology assist students to use their insights from real world situations to support abstract thinking The Program; - Has worked to create and implement a curriculum that uses technology to link mathematics to the real world for the middle secondary years. The focus was the mathematics of change and variation, a general theme which underpins much of the curriculum but most especially algebra. - Uses a range of “real-world interfaces” which schools are only beginning to use. These include software enabling analysis of digital photos and video (e.g. of movement of a fair ground ride), dynamic control of simulations, and data logging devices. - Uses “Maths analysis tools” (i.e. spreadsheets function graphing software and computer algebra systems (CAS), on both calculators and computers) which work with abstract mathematical representations. The first two of these are now firmly established in schools; the last is now the subject of experimentation around the world.
MATHS IN THE WORKPLACE	*Maths In the Workplace* is a collection of photocopiable worksheets

Blake Education	which feature the application of mathematical knowledge and techniques in various workplace contexts. Each topic is self-contained, and in most cases, an electronic calculator or spreadsheet program would be useful. **Versatile Uses** - Supplementary classroom lessons - Homework activities - Reinforcement of learning - Extension work for advanced students - Preparation for assessment - Exam revision **Teaching Benefits** - Creative teaching ideas - Developing greater student interest and understanding - A fresh approach to a topic or lesson - A way of targeting student weaknesses - Suitable for individual or group work - A variety of activities for home study
MATHS SKILLS FOR LIVING AND MATHS SKILLS FOR WORK ***Pheonix Education***	Teacher resource books designed to help develop essential numeracy skills in students. The resource is intended for students aged 14 to 16, an age when such students may soon be entering the workforce and may also be living independently. The main purpose of the units is to develop essential numeracy skills, but students will also acquire a better understanding and knowledge of practical living and working skills, such as planning household tasks, nutrition, conversation skills, body language, assertive behaviour, personal safety, days and dates, budgeting and arranging social events. MATHS SKILLS FOR LIVING and MATHS SKILLS FOR WORKING can be used as a standalone resource for individual students or small groups with special needs as units of work for whole class activities They are particularly valuable resources for Life Skills Maths courses but are equally valuable for many students in mainstream Maths classes.
TEACHING MATHS IN CONTEXT -*ACER Press, written by Dave Tout and Gary Motteram*	The resource outlines the case for teaching maths in context and outlines different options and strategies for teaching maths and numeracy in real life contexts.
TECHNICAL MATHEMATICS ***CENGAGE NELSON MATHEMATICS*** **Mathematics for the technologies** **Mathematics for industrial technicians** **Math Skills for the Sciences**	This resource provides readers with necessary mathematics skills. Mathematics provides the essential framework for and is the basic language of all the technologies. Mathematical, problem-solving, and critical thinking skills are crucial to understanding the changing face of technology. It presents the following major areas: fundamental concepts and measurement; fundamental algebraic concepts; exponential and logarithmic functions; right-triangle trigonometry; the trigonometric functions with formulas and identities; complex numbers; matrices; polynomial and rational functions; basic statistics for process control; and analytic geometry. An excellent learning aid and resource tool for engineers, especially computer software, hardware, and peripheral manufacturers. Its comprehensive appendices make this an excellent desktop reference.
CONSUMER AFFAIRS	Consumer Affairs Victoria has produced a number of FREE resources

VICTORIA - *CONSUMER STUFF* www.consumer.vic.gov.au	called *Consumer Stuff* that have an applied learning focus using real-life scenarios. There are free teacher resources in the areas of Maths, English and Commerce alongside Health and Wellbeing and Consuming Planet Earth. All are already mapped against VELS and VCAL. They have real life based activities Follow the links to the **Publications** page and then to the **Teachers** page where they will be able to download the pdfs or order hard copies

Teacher Acknowledgements

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