Chief Scientist

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THE AUSTRALIAN ASSOCIATION OF MATHEMATICS TEACHERS INC.

AUSTRALIAN INDUSTRY GROUP

Tackling the School–Industry Mathematics Divide

The teaching of mathematics in secondary schools and the use of mathematical skills in the workforce are very different.

Students who are mathematically capable at school often have difficulty transferring this ability to the workplace.

Our society needs a much better alignment between the teaching of mathematics in school and its application in the workforce.

This issue was tackled by the Australian Association of Mathematics Teachers and the Australian Industry Group with support from the Office of the Chief Scientist in a project entitled 'Identifying and Supporting Quantitative Skills of 21st Century Workers'.

The project examined the relationship between workplace mathematics and school practices to identify:

- gaps between numeracy and quantitative skills in senior schooling and the expectations of modern workplaces;
- how mathematical skills are understood and used in workplaces compared to classrooms;
- quantitative skills in use in workplaces; and
- how to support the transfer and application of mathematical skills required in workplace contexts.

Key messages

The application of mathematics in the workplace is not straightforward and goes beyond a command of 'core' or basic mathematical content. Workers perform sophisticated functions which require confidence to identify, use and apply mathematical skills in problem-solving situations and knowledge of the consequences of the procedures. Workers need a blend of the following:

- ability to recognise and identify how and when mathematics is used in the workplace;
- an understanding of 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 using and applying mathematics.

There is a gap in the ability of young people to integrate these skills in the workplace. Current school teaching approaches generally emphasise these skills 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.

A project of the Australian Association of Mathematics Teachers and the Australian Industry Group, supported by the Office of the Chief Scientist

The case study approach

Twelve teachers 'drilled down' and examined twelve volunteer workplaces. These included 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 and how these skills were acquired;
- patterns and common characteristics in the examples of the use of mathematics;
- models of future practice of transfer of mathematical skills to the workplace; and
- investigating the skills workers needed for the job and what they currently have.

> "You use mathematics everywhere: you need to know what you're looking for with mathematics—don't trust machines. Math drives design: area, 3-D, 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

The place and importance of mathematics

- Mathematics is extremely important in all of the companies involved.
- Changing work practices generate new demands for mathematical skills, particularly in efficiency, innovation, quality and continuous improvement.
- Managers and Supervisors consider mathematics very important in 'maintaining operations' and the 'routine procedures' of a company.

What mathematics is used in workplaces?

The level and scope of mathematics used by the workers observed, and required by employers, was generally consistent with the Essential or General subjects of the new Senior Years Australian Curriculum: Mathematics. Although the skills observed appear to be fundamental, it is their use and application in work contexts that is not straightforward.

The mathematics used is never required in isolation, in contrast with common practices in schooling.

> "This is one of the most interesting aspects/concepts of this project. The relationship between workplace mathematical skills and school mathematics could be described as 'distant' at best."
>
> – Teacher observation

How was mathematics used in the workplaces?

Mathematics is applied in both routine and complex tasks requiring sophisticated use of fundamental mathematical skills and 'judgement' or 'problem-solving' procedures. Workplace mathematics is performed differently to school mathematics. Mathematical demands may be present 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 work is becoming more common because of its importance in improving processes and this includes using mathematical reasoning and ideas through 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 perception is that technology is transforming workplace practices and the use of technology has changed the mathematical skills required – while not reducing the need for mathematics. Through technological change, mathematics has become more important and more embedded in the role of the modern worker.

The extensive use of technology has changed the way that work is done, and also the work itself – more sophisticated processes and analyses can now be done using technology.

Workers need to be more mathematically competent in order to understand the processes being undertaken, to assess and reflect on the accuracy and appropriateness of results, and understand and interpret the information produced by these analyses.

> "Workers now need experience in using spreadsheets. The algorithms consultants use are becoming more intensive and sophisticated. Expectations are that we are able to produce more meaningful reports."
>
> – Workshop Manager, NSW

Quantitative skills

The following is a summary of the quantitative skills identified in the workplaces. These are detailed in the Quantitative Skills Map developed by the project.

Measurement

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 and describing using suitable language and symbols;
- choosing appropriate formulae 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. Estimations can take the place of accurate calculations where precision is not required, or can be used to check mentally whether an error has been made.

Number skills—undertaking calculations

Workers apply basic mathematical concepts to calculate workplace information. Even when using technology, workers think through a problem to work out the right calculations to perform. They also need to know how to use the technology.

Multiplication, addition and subtraction: performed on whole numbers (for product quantities) and decimals (associated with measurements and money) on a daily basis.

Percentages: calculated by workers and apply to many functions in the workplace in order 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 by workers in the course of their jobs 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.

Many 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. They are often involved in reading and interpreting some aspects of plans and diagrams—particularly with an array of symbols and measurements. Workers interpret scales in diagrams, solve problems using plans, drawings and diagrams and create and investigate shapes and their representation.

Graphs, charts and tables

Workers use tables of product sizes, specifications and costs on a daily basis. The ability to interpret mathematical data is essential to the workplace, particularly in problem solving and quality improvement. They need to read, interpret and transform data from charts and spreadsheets; interpret statistical data to monitor quality of products and recognise trends in data.

Evaluation, critique and modelling using mathematical concepts

Many tasks involve workers in problem solving and decision-making using mathematical skills. They use mathematical problem-solving techniques to investigate and solve 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.

Implications for teaching and learning mathematics

Teachers should be provided with information about the wider uses and applications of particular mathematical ideas in the workplace.

There is a need to improve the connections between mathematics in schools and in the world of work for young people. In the workplace, the mathematical skills are placed into a complex, problem based 'whole' (the process) and 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 interpret, understand and use mathematics in a range of familiar and unfamiliar contexts.

It is more important than ever before for teachers to consider how they teach as well as what they teach—what and how cannot be separated when developing skills in key areas such as critical thinking, communication, collaboration, and mathematical modelling.

Given that the transfer of mathematical skills to the workplace is not straightforward, there is a need to promote the teaching of mathematical skills and understandings in a way that encourages connections between mathematics and the real world and on the transfer of skills. 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.

Identifying and Supporting Quantitative Skills of 21st Century Workers

The Final Report and full Quantitative Skills Map are available from the websites below:

- The Australian Association of Mathematics Teachers www.aamt.edu.au
- The Australian Industry Group www.aigroup.com.au
- The Office of the Chief Scientist www.chiefscientist.gov.au

This project was conducted with the assistance of funding provided by the Australian Government Department of Industry through the Office of the Chief Scientist.

Recommendations

Continuing and sustained dialogue and collaborative effort between mathematics teachers, their schools, industry, governments and other stakeholders are essential to address the five key areas for action identified in the project's recommendations:

1. Generate national awareness and understanding of how mathematics is conceptualised and used in workplace settings.
2. Research and develop strategies for mathematics teaching in schools which meet contemporary workplace requirements.
3. Ensure that the *Australian Curriculum* provides guidance for the transfer of mathematical skills to the workplace .
4. Develop a strategy for supporting change in schools.
5. Develop a strategy for supporting development of mathematical capability and numeracy in the workplace.