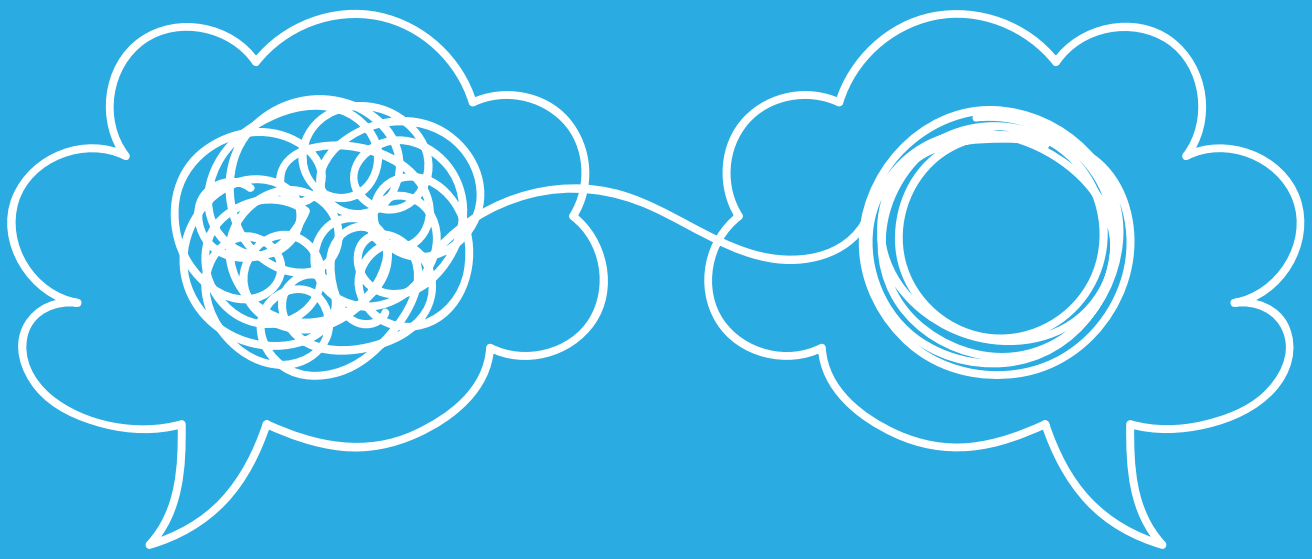
THE MATHEMATICAL ASSOCIATION OF VICTORIA

THE COMMON DENOMINATOR 1/21

LINKING VALUE AND MATHS ANXIETY



INSIDE

Dr Sarah Buckley, Senior Research Fellow, Australian Council for Educational Research

Across school communities, the start of the school year brings new challenges and opportunities. Some students or teachers may have decided to make the new year about improving their mathematics/mathematics teaching or focussing more on mathematics. However, for others the prospect of new mathematical challenges will produce the tension and worry characteristic of mathematics anxiety. For these students and staff, their anxiety may be an obstacle to future improvement with research showing that mathematics anxiety can negatively impact on mathematical performance and mathematics-related choices (Ashcraft & Kirk, 2001; Ma, 1999).

When discussing mathematics anxiety and how it relates to other academic concepts, some people find it surprising to learn about its relationship with value. Many people assume that students that are mathematically anxious do not value mathematics as a tool or subject area.

Continued on page 3

THE COMMON DENOMINATOR
The MAV's magazine published for its members.

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FROM THE PRESIDENT

Michael O'Connor

RISING TO THE CHALLENGE AND EXCEEDING ALL EXPECTATIONS

One hundred and ten sessions, eight hundred participants and an incalculable number of hours of preparation over many months. This was MAVCON 2020: Engaging Mathematics. In a year beset by challenges I want to begin this article by congratulating the conference team and the presenters on rising to the occasion! Particular thanks to Jacqui Diamond and Ann Downton without whom the conference would not exist.

A benefit of the December 2020 conference's digital format is that all of the sessions were recorded and the resource material loaded to the conference website. For teachers who attended the conference there is automatic access to all the material for the day (or days) you attended. It is also possible for teachers and schools who wish to take advantage of this repository for professional learning throughout 2021. The pricing schedule can be found on the MAV website.

In particular, I would encourage everyone to watch James Tanton's keynote on *Exploding Dots*. James provides a thoroughly engaging session connecting place value, different bases and algebra together into a beautifully sequenced whole. I found it most enlightening as James took us on a journey through mathematics that we already know and showed it to us from a new perspective. It is akin to walking along a newly found bush trail and arriving at a clearing that we know we have seen before, but never quite from this perspective.

Understanding mathematics is more than just being able to perform routines and arrive at the correct answers. It is about seeing the world around us in ever greater depth and clarity.

As teachers, it is part of the development of our craft that we remain open to exploring and seeing in new ways so that we can better guide our students.

2020, while challenging in so many ways, provided us with a wealth of examples of why mathematics is fundamental to civilisation.

Statistics, disease modelling, e-commerce, communication, genome sequencing, the list goes on. It was a year where conversations and decisions required new and deeper understanding of mathematical ideas by people in the street.

Educationally, 2021 will be a year of preparing for change. The VCE and the Australian Curriculum are both being reviewed. Implementation of the changes resulting from these reviews will occur over the next couple of years. MAV will provide a voice for mathematics teachers in these processes and professional learning opportunities, as well as support as they are implemented.

I am sure that for many of us, the process, or even the thought, of yet another change to what we teach can be daunting. The world moves on though. Our choice is in how we engage with change. We have an opportunity to look anew at something we think we know from a new perspective and greater experience.

The support of its members is MAV's core purpose. Make the most of what the association has to offer and actively engage with other members in deepening understanding and providing the best possible outcomes for the students in our care.

LINKING VALUE AND MATHS ANXIETY

Dr Sarah Buckley, Senior Research Fellow, Australian Council for Educational Research

CONT. FROM PAGE 1.

But if you think about anxiety as an emotion, it is not possible to be anxious about something unless there is value attached in some way. Pekrun's control-value theory of achievement emotions considers mathematics anxiety as the emotion experienced when an individual believes they cannot exert much control over their mathematical learning and this combines with some kind of valuing of mathematics (Pekrun, 2006). Wentzel and Wigfield (1998) describe academic value:

- interest value (I value mathematics because I am interested in it and I like it)
- utility value (I value mathematics because it is useful for my career and/or future) and
- attainment value (I value mathematics because I consider it important).

Attainment value could be reported by students who also present with negative attitudes towards mathematics. The myth that 'being good at mathematics means that you are smart' might lead someone to value mathematics because of a perceived link to general intelligence. Their attainment value combined with personal judgements of poor control over mathematical learning may cause them to experience mathematics anxiety.

An area where the relationship between anxiety and value is particularly evident is teacher mathematics anxiety. The anxiety that some teachers feel about mathematics and/or teaching mathematics often comes from a place of valuing mathematics. These teachers know that mathematics is important and want to make sure they can teach their students effectively. This is why it is so important to provide effective support for colleagues who are anxious about mathematics Unfortunately, teachers and students who experience high levels of mathematics anxiety often procrastinate when engaging in mathematics or avoid it altogether. This can present as a huge obstacle to mathematics leaders who want to help their colleagues overcome their anxiety and improve their mathematics teaching confidence.

There is a growing conversation in the research literature (e.g. Buckley, Reid, Good, Lipp & Thomson, 2016; Maloney, Schaeffer & Beilock, 2013; Park, Ramirez & Beilock, 2014; Ramirez, Shaw & Maloney, 2018) that psychological strategies are an important part of the process of addressing mathematics anxiety and avoidance of mathematics. This is particularly the case for mathematically anxious teachers who may find that their anxiety stops them from accessing resources to strengthen their content and pedagogical content knowledge. They may also feel like their mathematics anxiety is a chronic condition that they are unable to escape. In these cases where anxiety is acting like a barrier, psychological strategies like expressive writing, mindfulness and reappraisal can help teachers to reduce the symptoms of their mathematics anxiety to a more manageable level. From here, these teachers may feel more comfortable to seek support from colleagues and may be more open to opportunities for developing content and pedagogical content knowledge and improving mathematics teaching confidence.

Figure 1. The impact of mathematics anxiety on mathematics performance.

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For more information about mathematics anxiety and some of the research that underpins the concepts discussed here, Sarah Buckley has written a monograph for the Victorian Department of Education and Training, visit www.education.vic.gov.au/school/teachers/teachingresources/discipline/maths/Pages/evidence-and-research.aspx.

The monograph is one of eight that has been commissioned by the Department to support principals, learning leaders and teachers better understand and tackle important issues related to mathematics using evidence-based perspectives.

YOUR MAV MEMBERSHIP

MAV is a highly active association with over 450 individual members, and nearly 900 institutional members, including schools. This provides membership benefits to a growing network of over 13,500 mathematics educators.

MAV supports its members by working with experts including leading education academics and researchers, education consultants, exemplary classroom teachers, the Victorian Department of Education, The Victorian Curriculum and Assessment Authority (VCAA), and various education partners to provide services in the interests of members and the wider community.

MAV's core services include:

- Professional learning
- In-school consulting
- Professional advice
- Annual conference
- Primary and early childhood conference
- Student activities
- Newsletters, magazine and journals
- Publications and resources through MAVshop
- Advocacy and representation

HOW I CAN I GET INVOLVED IN THE MAV?

MAV depends on its members for success. Extend your professional learning and get involved in MAV's activities:

- Present at MAV's annual conference
- Join one of our networks, or start your own with MAV support
- Write for MAV's journals *Vinculum* and *Prime Number* and/or the MAV magazine, *Common Denominator*.
- Join committees and working parties

MATHS TALENT QUEST

FOR STUDENTS OF ALL YEAR LEVELS

GET INVOLVED IN 2021

The MTQ aims to promote interest in mathematics and foster positive attitudes amongst students, teachers and parents. The focus is on the process of mathematical investigations.

WHO CAN ENTER?

Individuals, small groups or classes from Prep - 12.

HOW DO I ENTER?

On the MAV website: www.mav.vic.edu.au/student-activities/maths-talent-quest.html

WHEN DO I ENTER?

Registration opens Monday 19 April and close Monday 26 July.

JUDGING

Online judging will take place from 16-20 August 2021.

For more information contact jbowden@mav.vic.edu.au or www.mav.vic.edu.au/student-activities/maths-talent-quest.html

INVESTIGATE

COMMUNICATE

COLLABORATE

WORK LIKE A MATHEMATICIAN

THE MATHEMATICAL ASSOCIATION OF VICTORIA

TO FIND OUT MORE VISIT WWW.MAV.VIC.EDU.AU OR CALL +61 3 9380 2399

- Develop resources
- Pilot mathematics initiatives
- Develop a PD event at your school or venue
- Judge the MTQ awards, or
- Organise a maths games day for your region.

THERE IS A MEMBER CATEGORY FOR YOU

- Individual member (teachers, academics, student teachers and those with an interest mathematics education)
- Institutional member (primary and secondary schools and early childhood centres)
- Associate member (industry partners or resource providers)

EDUMAIL EMAIL CHANGES

Edumail email addresses have now changed and MAV is keen for members to update their details via our website. It only takes a minute.

- Click the blue *Login* button at the top right of the website to login using your current email address and password.
- Click the blue *My Details* button at the top right of the website.
- Select *Update my details*
- Select *Click here to update your email address*, add your new email and current password to update.

You should have received your membership renewal notices for 2021. We look forward to you renewing your support for MAV, and ask you to pay your invoices as soon as possible.

Thank you to those who have already renewed.

If you or your school have any questions regarding membership, please contact Michael Green, mgreen@mav.vic.edu.au or telephone 9380 2399.

STATEWIDE MATHEMATICS GAMES DAYS 2021

- A new setting for mathematics
- Novel and challenging tasks
- FUN!

A Maths Games Day is an opportunity for students to develop their mathematical talents and thinking skills in a setting where maths is regarded as fun and worthwhile with like-minded students from a diverse range of schools.

It is an ideal way for students to participate in mathematical activities without the usual class room pressures and is a very effective vehicle for getting young people – particularly in the middle years of schooling – excited about maths. Problem solving and mathematical games address the Victorian Curriculum proficiency strands.

Questions? Contact Jen Bowden (Primary) or Helen Haralambous (Secondary).

LEVEL	DATE	HOST SCHOOL
Year 3	Friday 6 August	Derrimut Primary School, Derrimut
Year 4	Friday 20 August	Lowther Hall, Essendon
Year 5	Tuesday 27 July	St Patricks Catholic Parish Primary School, Mentone
Year 5	Tuesday 27 July	PEGS, Essendon
Year 5/6	Friday 3 September	Kilmore Primary School
Year 6	Friday 10 September	Lumen Christi, Point Cook
Year 6	Friday 10 September	Genazzano, Kew
Year 7	Monday 16 August	Overnewton Anglican, Taylors Lakes
Year 7	Monday 16 August	Waverley Christian College, Narree Warren South
Year 8	Wednesday 25 August	PEGS, Esssendon
Year 8/9	Wednesday 11 August	Federation University, Gippsland
Year 9	Thursday 12 August	Williamstown High School, Williamstown
Year 10	Wednesday 1 September	Trinity Grammar, Kew
Year 11/12	Monday 23 August	TBC

THE MATHEMATICAL ASSOCIATION OF VICTORIA

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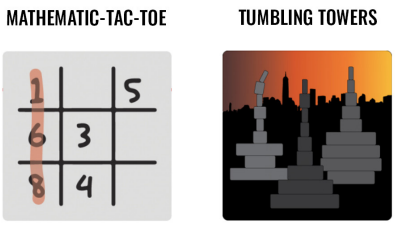
INTENTIONAL FUN

Andrew Lorimer-Derham, Inventor Think Square and Mirrogram

If you asked your learners to choose three words to describe maths with, what do you think they'd say? Have a look at Figure 1. On the top are the words your average person associates with maths. The larger the text the more frequent the response. On the bottom are the most common words mathematicians associate with maths.

The disposition of your average learner presents an enormous barrier for maths teachers. Thankfully this is something that can be changed. For the last seven years, it has been my privilege to help students (and teachers) enjoy maths through what I call 'intentional fun'.

An article explaining intentional fun seems pretty counterintuitive, so what I'd like you to do is visit thinksquare.com.au/play and spend 5-10 minutes having some intentional fun. Select *Tumbling Towers* or *Mathematic-tac-toe* (preferably both) and see how far you can get. The remainder of this article won't make sense until you do.



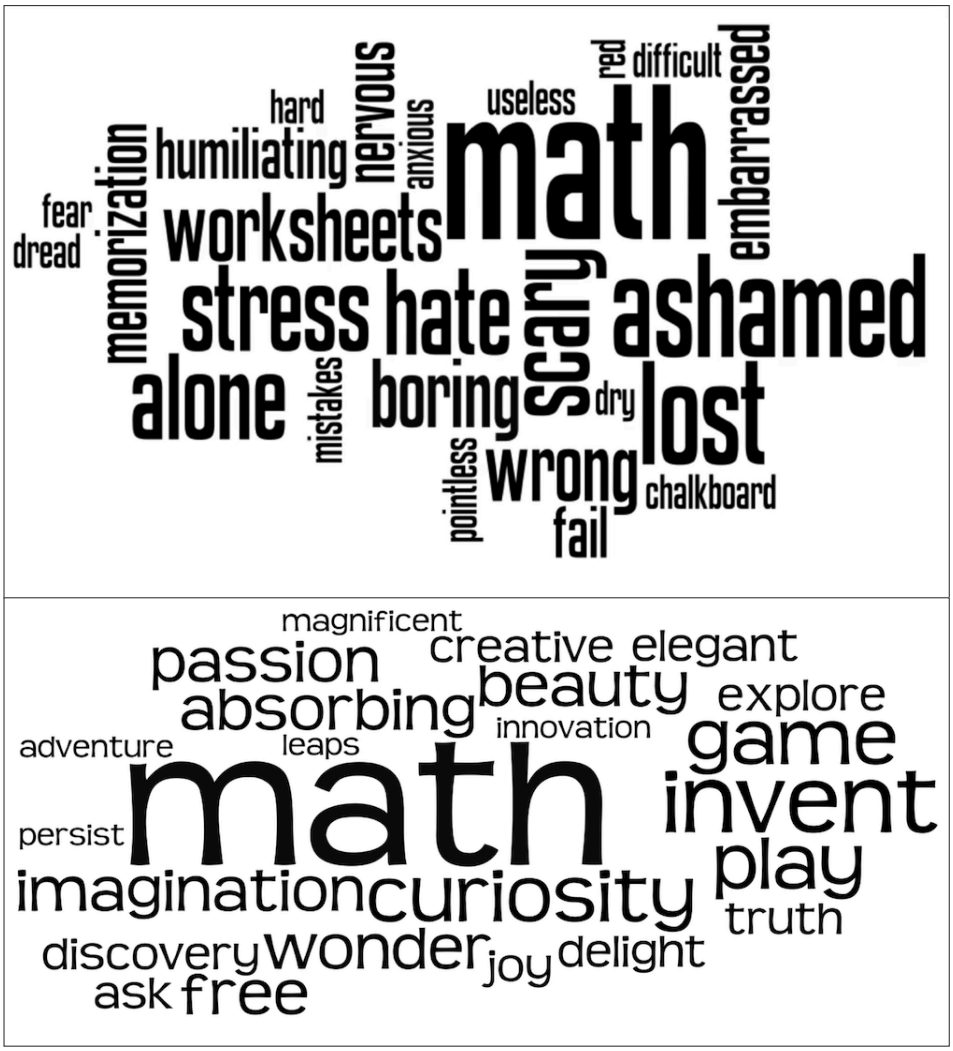


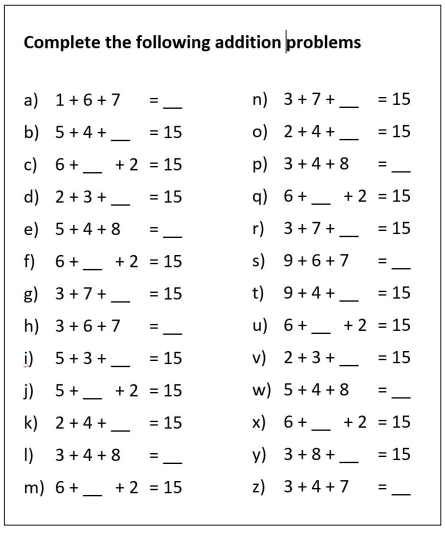
Figure 1. Words that most people associate with maths (top) and words that mathematicians associate with maths (bottom). Word clouds gathered by Tracy Zager.

WELCOME BACK. I HOPE YOU ENJOYED YOURSELF.

Now have a look at the worksheets (Figure 2). How long would they take your average learner to complete? How would they feel about them? What sort of thinking do they require? Do they encourage risk taking, creativity, imagination? These worksheets are the equivalent of the games you've just played. Let's compare the two and see how they stack up.

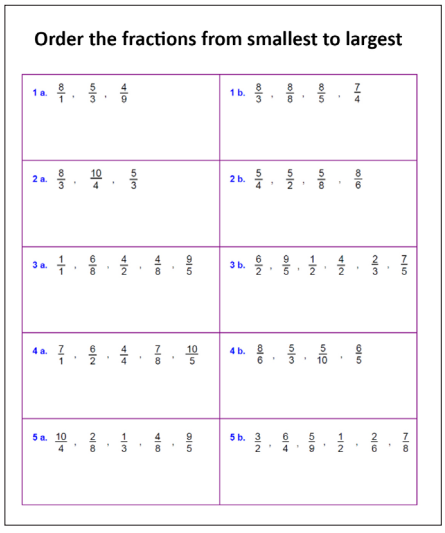
EFFICIENCY

During professional development workshops I like to get teachers to estimate how long these worksheets would take their average learner to complete. Their estimates consistently exceed the time it would take to play the game equivalent. If maths was about completing worksheets then well-designed games would win on that front.



Complete the following addition problems

a) 1 + 6 + 7 = __
b) 5 + 4 + __ = 15
c) 6 + __ + 2 = 15
d) 2 + 3 + __ = 15
e) 5 + 4 + 8 = __
f) 6 + __ + 2 = 15
g) 3 + 7 + __ = 15
h) 3 + 6 + 7 = __
i) 5 + 3 + __ = 15
j) 5 + __ + 2 = 15
k) 2 + 4 + __ = 15
l) 3 + 4 + 8 = __
m) 6 + __ + 2 = 15
n) 3 + 7 + __ = 15
o) 2 + 4 + __ = 15
p) 3 + 4 + 8 = __
q) 6 + __ + 2 = 15
r) 3 + 7 + __ = 15
s) 9 + 6 + 7 = __
t) 9 + 4 + __ = 15
u) 6 + __ + 2 = 15
v) 2 + 3 + __ = 15
w) 5 + 4 + 8 = __
x) 6 + __ + 2 = 15
y) 3 + 8 + __ = 15
z) 3 + 4 + 7 = __



Order the fractions from smallest to largest

1a. $\frac{8}{1}, \frac{5}{3}, \frac{4}{9}$
1b. $\frac{8}{3}, \frac{8}{6}, \frac{8}{5}, \frac{7}{4}$
2a. $\frac{8}{3}, \frac{10}{4}, \frac{5}{3}$
2b. $\frac{5}{4}, \frac{5}{2}, \frac{5}{8}, \frac{8}{6}$
3a. $\frac{1}{1}, \frac{6}{8}, \frac{4}{2}, \frac{4}{8}, \frac{9}{5}$
3b. $\frac{6}{2}, \frac{9}{5}, \frac{1}{2}, \frac{4}{2}, \frac{2}{3}, \frac{7}{5}$
4a. $\frac{7}{1}, \frac{6}{2}, \frac{4}{4}, \frac{7}{8}, \frac{10}{5}$
4b. $\frac{8}{6}, \frac{5}{3}, \frac{5}{10}, \frac{6}{5}$
5a. $\frac{10}{4}, \frac{2}{8}, \frac{1}{3}, \frac{4}{8}, \frac{9}{5}$
5b. $\frac{3}{2}, \frac{6}{4}, \frac{5}{9}, \frac{1}{2}, \frac{2}{6}, \frac{7}{8}$

Figure 2.

PROFICIENCY

In addition to learning to follow a process, these games require an enormous amount of mathematical reasoning by making if/then statements, deciding on the best place to position numbers, using logic and proportional reasoning to predict outcomes, etc. Games require all four proficiencies while worksheets usually require just one (fluency).

Side note: Fluency is important, but only when it is applied to solve problems, reason and understanding the world around us. Fluency is a tool like a hammer. It's only useful if you use it to build something.

DISPOSITIONCY!

If we think back to the words people associate with maths, worksheets tend to elicit terms like 'boring', 'lost' and 'wrong'. The alternative invites curiosity, play, imagination and creativity – all things mathematicians associate with maths.

REAL WORLD APPLICATION

What I also love about games is that they are dynamic, like maths is in real life. Both cause you to think on your feet, respond, adapt, rethink your strategy and reflect, because there is rarely a 'one size fits all' solution to problems. For example, before we purchased solar panels, I decided to work out how long it would take before we'd break even. Being a maths teacher, I went into full-nerd mode and performed a crazy number of calculations. I even considered the extra interest we'd pay on our house loan by spending on solar and not having that money in our offset account! Despite my best efforts, my calculations were wildly out as electricity prices increased as did the rebate for selling power back to the grid. I also hadn't factored in having kids, buying a new fridge or working from home for most of 2020! For those curious we broke even in around 5 years (I had calculated 7!)

SKILLS FOR THE FUTURE

The world is constantly changing. As educators our job is to prepare our learners with the skills they need to thrive. The days of repeating a process to pay the bills are numbered. Skills that require little creativity are quickly being replace by robots.

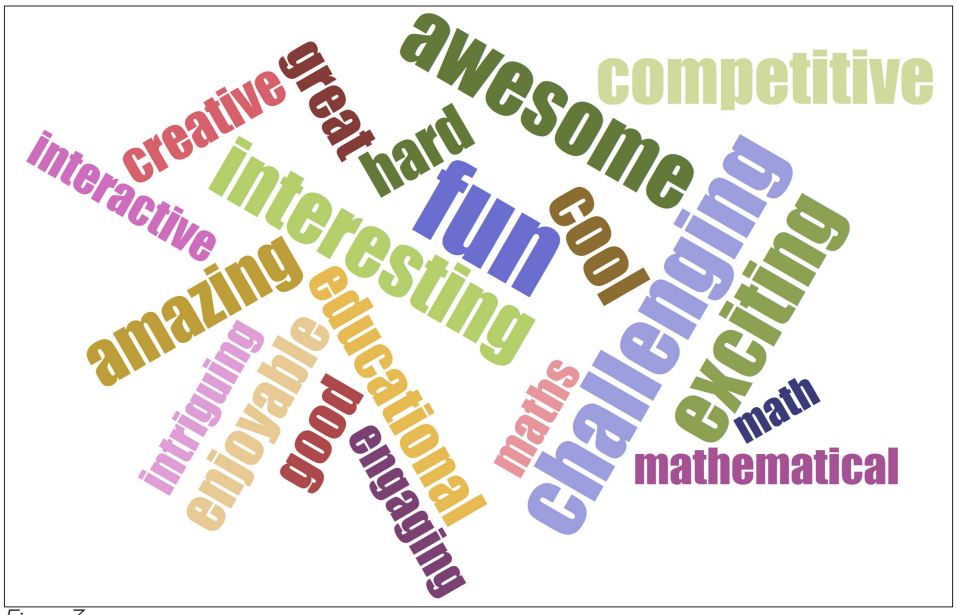


Figure 3.

Figure 4. Students enjoying an intentional fun workshop.

Einstein was way ahead of his time when he said back in 1931, 'Imagination is more important than knowledge.' This is true now more than ever. Let's give our learners opportunities to create, discover and play. You'd be amazed at what happens to students' disposition when you do. At the end of intentional fun workshops, I often ask students to describe the session with three words. Figure 3 shows the twenty most common words from over 350 students at 25 different schools from Years 3-10.

START SMALL BUT PLEASE START

The power to shift your learners' disposition toward maths rests with you. Your efforts make a difference, no matter how small. So start today. There are plenty of free games and ideas to get you inspired on the Think Square website, thinksquare.com.au.

If you'd like support building more intentional fun in your maths classrooms or would like to share a success story, please get in touch, andrew@thinksquare.com.au.

NEW!

NELSON MATHS

WORKBOOKS

YEARS 7–10

200 PAGES OF CLEAR MATHS LEARNING!

Introducing *Nelson Maths 7–10*, a new series of write-in workbooks. With 200 pages of **worksheets, puzzles, topic assignments and 40 weekly homework assignments,** these workbooks are designed for structured maths learning anytime and anywhere.

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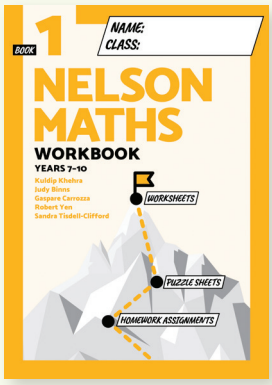

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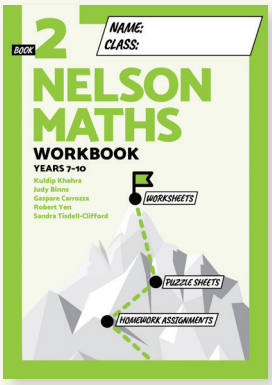

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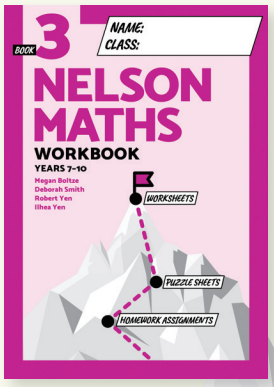

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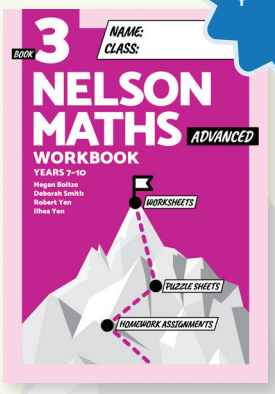

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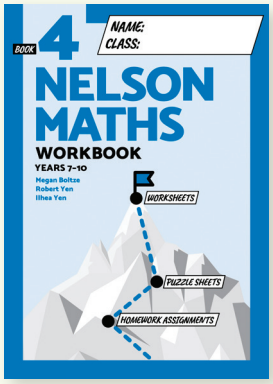

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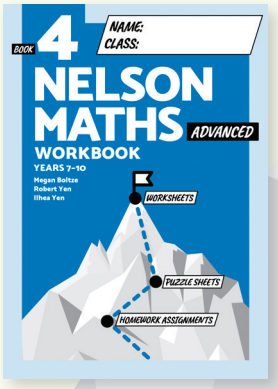

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ONE MINUTE WITH PETER SULLIVAN

I'M..

Peter Sullivan and an Emeritus Professor from Monash University. Even though I am retired from the university I still work on research projects and with schools and systems. I like to lead professional learning on approaches to engaging inclusive mathematics teaching.

THE BEST PLACE I'VE EVER BEEN WAS...

Wilson's Promontory. I have travelled on five continents and have been to cultural, historical and natural highlights around the world but the magnificent scenery, isolation and natural state of the mountains, rivers and beaches of the Prom provoke both wonder and peace.

THE BIGGEST LESSON 2020 TAUGHT ME...

To live your life while you can. Even though I missed out on overseas and local adventures due to the virus, I was able to look back on happy memories of places I have been and people I have known. Even now, future prospects are more likely to be local.

MY HOPES FOR 2021 ARE...

That we face life and the world without fear and learn to value and enjoy safe social interactions wherever they might be.

AN EFFECTIVE EDUCATORS CAN...

Be a learner, can aim for improvement, can make decisions based on evidence, can examine critically every belief, and can think for themselves.

MATHEMATICS EDUCATION IS DEAR TO ME BECAUSE...

The thrill of having insights is available to nearly everyone, and for me the purpose of mathematics education is to explore how to provoke self generated insights about mathematics or its uses and to foster curiosity in all teachers and students.

Emeritus Professor Sullivan.

THE SIMPLEST BUT MOST EFFECTIVE PIECE OF TEACHING WISDOM IS...

We have two ears, two eyes and one mouth and we should use them in that ratio.

ACADEMIA IS THE RIGHT PLACE FOR ME...

While I enjoyed my classroom teaching, I have had the privilege of working with prospective and practising teachers and helping them to broaden their thinking of what is possible with education and mathematics education in particular.

I GET JOY FROM...

Seeing my grandchildren develop and mature, seeing my own children as parents, keeping old friends and making the occasional new ones, and learning about myself and the world.

I'D NEVER LEAVE HOME WITHOUT...

Checking that my socks match and my shoes match (although that sometimes does not happen).

COFFEE OR TEA?

I have one of each every day usually made at home (even without lockdown).

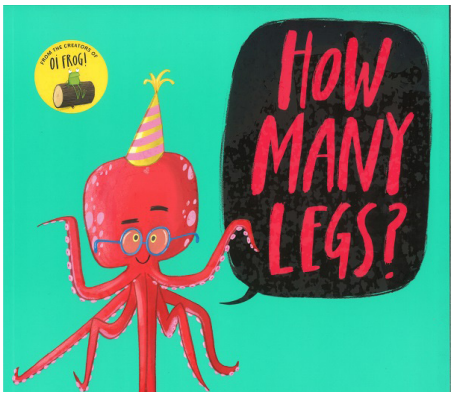
THE BIGGEST CHANGE I'D LIKE TO SEE IN EDUCATION IS...

For school leaders and teachers to make decisions on school and class organisation, pedagogy, assessment or anything else based on locally collected data (of which schools have plenty) rather than on the latest fad.

Who would you like to see profiled in *Common Denominator*? Email suggestions to office@mav.vic.edu.au.

HOW MANY LEGS?

Cathy Epstein/Rodgers - Mathematics education consultant and School Numeracy Leader, St Peter's and St Paul's Bentleigh



AN ADVENTURE IN COUNTING

Did you know that if a squid rode in on a buffalo there would be 14 legs altogether? How would the count multiply if a centipede came wriggling by? And why does the entrance of a slug or maggot not affect the count?? These are some of the problems you can solve as you investigate this delightful story by Kes Gray and Jim Field.

But the big question is... *How many legs are at the party?*

It is party time and a weird and wacky variety of animals are invited! *How Many Legs* is a wonderfully creative story that can be an adventurous way to explore efficient strategies to count a large collection.

LEVEL 3 CLASS INVESTIGATION

The first time I read this to my Level 3 class we simply enjoyed the story and talked about all the different types of animals we saw, discussing how many legs each animal had. I asked the students to estimate how many legs they thought there were altogether at the party and write this on a post-it note. The students also shared the strategies they may have used to arrive at their estimation.

I revisited this page where the party organiser was trying to count the number of legs and asked. 'Was this the most efficient way to keep track of or work out the total number of legs?'

Discussion led to the conclusion that although it was a good way to track the number of legs, it would be hard to calculate how many legs by using just this poster and we could see how he lost count!

Number of legs	Tally (no. of animals with this many legs)	Total of legs
2 legs	𝍸 |	2 x 6 = 12 legs
4 legs	𝍸 |||	5 x 4 = 20 3 x 4 = 12 20 + 12 = 32 legs
6 legs	||	2 x 6 = 12 legs
8 legs	| Octopus	8 legs
10 legs	| Squid	10 legs
100	| Centipede	100
Total of legs altogether		174 legs

Table 1.

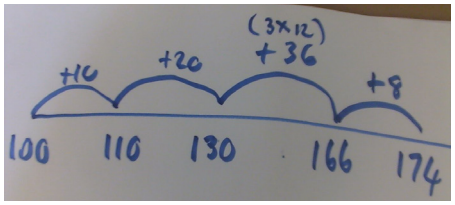
So what can we use to help us count the number of legs as each interesting guest arrives at the party?

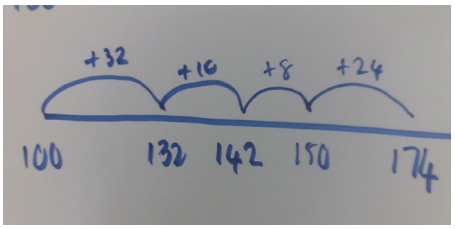
After much discussion we arrived at two ways that we thought we might test. Some children chose to use a 200 counting chart and counter so they could count on as the story developed.

While others decided on using a tally, marking against the number of legs as each animal arrived at the party and then collating the tally at the end. Table 1 shows how we calculated the total using the tally.

Counting with the 200 chart presented more challenges and discussion as the story developed. (E.g. what was the best way to add 10). While the tally evoked more discussion regarding efficient ways to multiply and add at the end of the story.

We calculated the total using an empty number line which in turn led to a rich discussion on the variety of strategies to add the collections of legs. Here are two different ways tallies were collated.





However we counted, in the end, we were unanimous in the decision that there were in fact 174 legs, not including the table! We then compared this with our estimate. How close were we? What was the difference between our estimate and the total?

As an independent follow up activity I put two scenarios on the board and asked the children to choose one to investigate:

Option 1: At my party I counted 36 legs. Who could have come to my party?

Option 2: At my party I counted 150 legs. Who could have come to my party?

Before we began, we looked at things we might need to consider before we got started and listed these on the board:

- The number of legs on different animals
- Are we including ourselves?
- Factors of 36 and 150
- Factors if we split numbers to calculate and solve e.g. 36 = 30 and 6 or 20 and 16 and 150 = 100 + 50

Although option 1 had a smaller number I knew the children would find this more challenging as they had to consider what goes into 36. With 150, many chose the option of beginning with a centipede as it had 100 legs, then 50 became an easier number to partition. (5 squid)

SOME OF OUR ANSWERS

Isla, who sometimes finds mathematics challenging chose 150 legs to have at her party. Initially she decided she was going to have 1 centipede (100legs), 4 squid (40 legs), 1 octopus (8 legs), and herself to get 150 legs.

She then changed her mind because she loves kittens and kicked the octopus out and instead invited 2 kittens to replace the 8 legs.

Sienna chose the number 36 and quickly found a number of ways to get the total number of legs including 2 squid (20 legs) 2 goats (8 legs), 1 duck (2 legs) and a bee who had 6 legs to bring the total to 36!

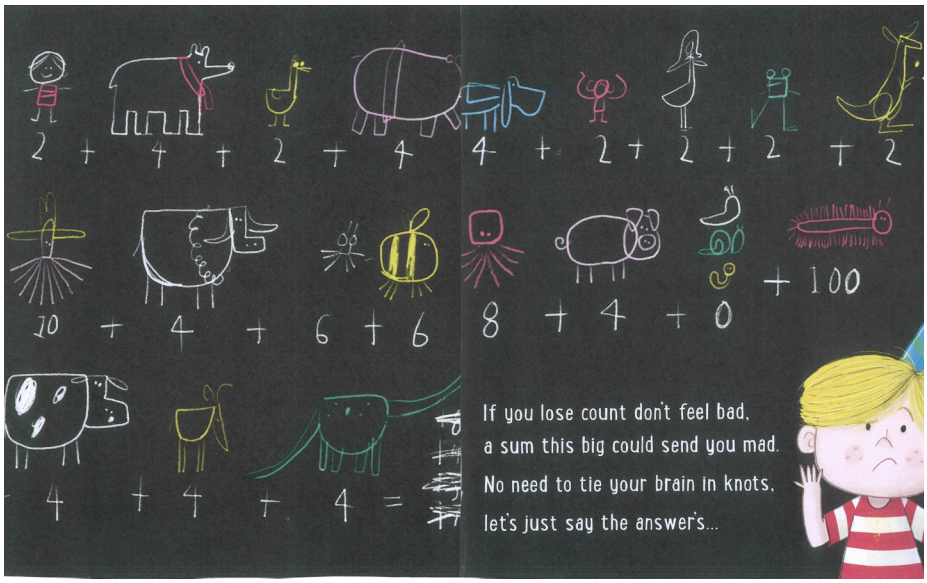
The children loved the task and all of them quickly got to work investigating.

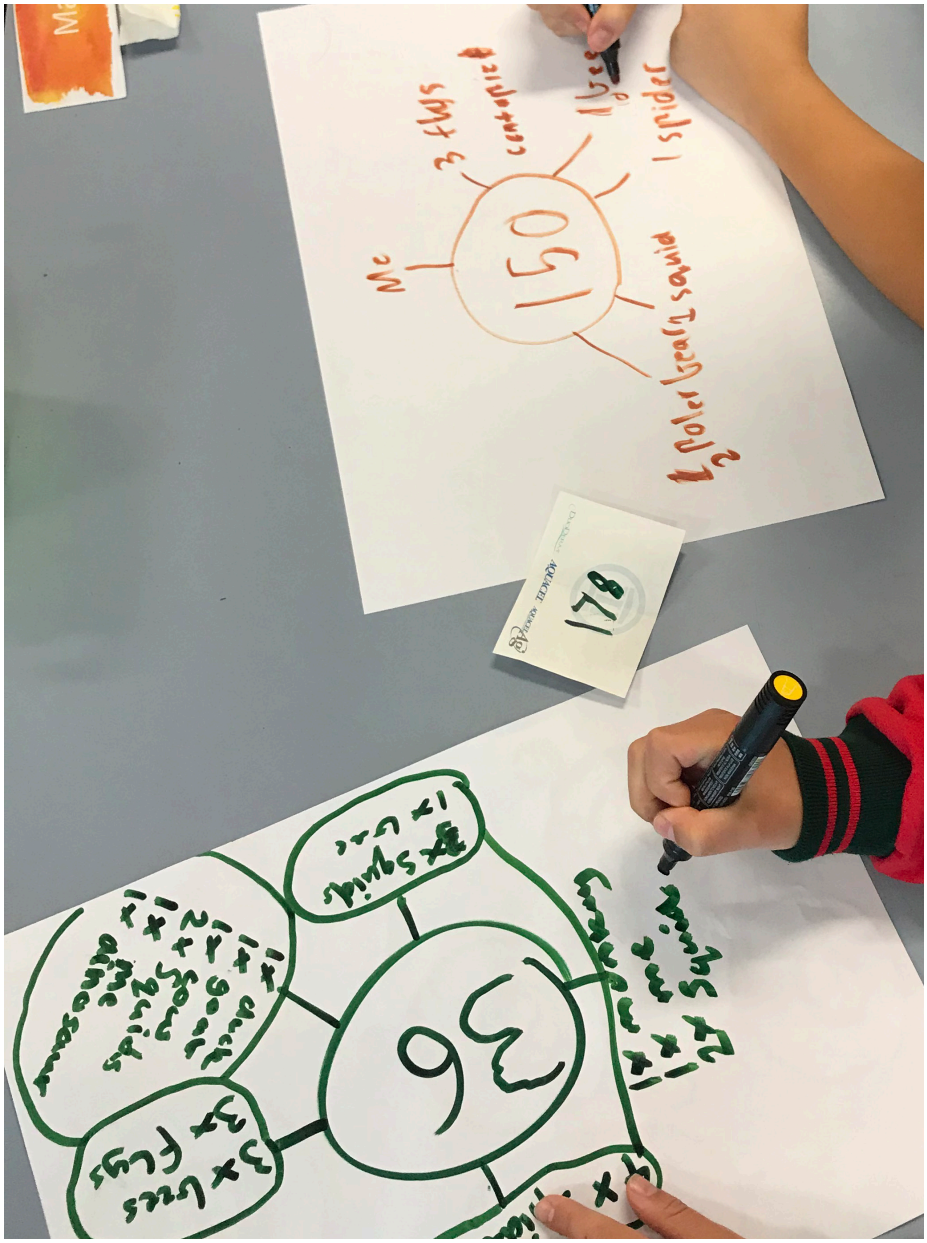
I plan to revisit *How Many Legs* as the children are quite keen to write their own version and give it to a friend to solve.

A FOUNDATION APPROACH

When investigating counting, our Foundation team also read *How Many Legs*, to their class and followed up with a creative task that involved counting legs on farm animals. The children were asked to grab a handful of farm animals, estimate the number of legs in their hand and then sort their animals in a way that may help them to count the total number of legs. (e.g. into groups of animals with 2 legs and animals with 4 legs etc). They then got them to write and draw number sentences explaining who came to their farm party.

This book is available from MAV's online shop, www.mav.vic.edu.au/shop.





STIMULATING THINKING

Jennifer Bowden, Helen Haralambours and Danijela Draskovic – Education consultants, Mathematical Association of Victoria

A picture sparks 1000 maths concepts! Use this picture as a prompt to stimulate thinking. If you have other ideas for investigations or lessons that could stem from the ideas here, add them to the conversation on our social channels. You can find us on Facebook, @mathematicalassociationofvictoria and on Twitter, @mav_info.

FOUNDATION - YEAR 2

- Estimate how many cubes are in the image. Can you explain your thinking?
- How could you sort the flags into groups? Think of another way you can sot them in groups.
- Name five different shapes you can see on the flags.
- There are a few different stars on the flags. Identify the different types of stars, how many points do they have? Are their sides always equal?
- Survey your family or friends. Which of these flags can they identify and name the country they belong to?
- The flags are on squares in this image, normally flags are represented on rectangles. List 3 – 6 other 2D shapes you know the names of.
- Name the features of a cube that distinguishes them from other 3D shapes.
- Look at the image of the American flag on the top of the cube. Can you explain what steps (flips, slides, turns) you would need to do to make it sit directly on top of the flag image on either side faces of the cube?
- Create your own flag that uses at least three colours and three 2D shapes.
- Choose one of the flags in the image, using mathematical language describe what the flag looks like to a peer. See if your peer can guess which flag you are talking about.

YEARS 3 AND 4

- Estimate how many cubes are hidden in the image. Justify your thinking.
- What fraction of the flags have red on them? Can you describe this as a percentage?
- Create a T chart or Venn diagram to explain the similarities and differences between a cube and a rectangular prism.
- If you were going to teach a younger child how to identify one third, which flag would you use? Why?
- There are many examples of right angles in the image above? Find three – six examples of acute angles.
- Research the countries each of the flags belong to. Create a data display or graph to show which of the continent of the world the flags belong to.
- Many different countries use the colours red, yellow and green.
    - How many different flags can you create with different combinations of these colours?
    - Research which countries have all these colours on their flag and locate these on a map.
- Choose a flag that has three or more colours. Using precise mathematical language, describe what the flag looks like to a peer. See if your peer can accurately draw the flag.
- The flag of the USA has 50 stars representing the 50 states and 13 stripes representing the 13 original colonies. If there were 9 cubes with 6 faces covered with the American flag, how many stars and stripes would there be in total.

YEARS 5 AND BEYOND

- Estimate what percentage of the cubes are hidden in the image. Justify your thinking.
- If you were choosing a cube at random from the visible cubes, what is the probability you would select one with the colour yellow on it?
- What is the probability of selecting two cubes in a row with black on them?
- Survey your family or friends. Which of these flags can they identify and name the country they belong to? Give each person surveyed a score as a percentage of the total flags.
- Create a Venn diagram to explain the similarities and differences between a cube, a rectangular prism and a parallelepiped.
- There are many examples of right angles in the image. Find at least two different examples of each of the following: acute angles, obtuse angles and reflex angles. Define each type of angle. Can you define the term ‘angle’?
- If the flag of Djibouti was placed on a square face, with the point where white, green and blue all meet is exactly in the middle, work out all the angles in the image (including the ones in the star).
- Describe the following countries’ flags to a peer using mathematical language. See if your peer can accurately draw each of the flags. Each flag has taboo words you cannot say in your description. Good luck!
    - Sweden. (Taboo word: cross)
    - Bahamas. (Taboo words: point/pointy)
    - South Africa. (Taboo words: ‘Y’, point/pointy)
- If you were going to teach a younger child how to identify the fractions one-third and one-quarter, which flag would you use? Why?

VCE SACS: MEASUREMENT

Andrew Stewart

THROWING A MATHS PROBLEM

Finding material for use in school assessed coursework can be a challenging experience. This article contains suggested task material for the geometry and measurement module in further mathematics based on questions from the MAV Trial Exam papers.

This paper draws on a number of ideas from a common theme to provide SAC material. Sporting fields or courts offer a rich diversity of opportunities on which to base tasks.

All dimensions – for equipment or field layout – given in the questions for the trial examinations are based on the actual dimensions as specified for each particular sport. These dimensions are meticulously detailed to ensure all events are set up in the same way. The International Amateur Athletic Federation (IAAF) has issued a downloadable technical manual (in two parts) that gives the specifications for each sport (IAAF, 2019). Chapters 1-3 in the first of these two parts contain the necessary information.

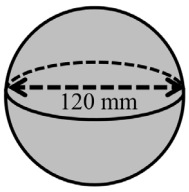
The shot put balls, discuses and hammers for male and female competitors are of different sizes and weights, so this gives an opportunity for similar figure problems. Details of these differences are given in Table 1. Some of these events also have different sizes for junior competitors which could also be taken into consideration. Some of this information was as follows (see Figure 1.)

Name	Men	Women
Shot	7.26 kg, 110 – 130 mm diameter	4.0 kg, 95 – 110 mm diameter
Hammer	7.26 kg	4.0 kg
Discus	2.0 kg, 22 cm diameter	1.0 kg, 18 cm diameter

Table 1. Specifications for shot, hammer and discus for men and women.

2017, Exam 2 Question 1

A shot put ball, as used in the shot put field event, is spherical in shape, has a smooth surface and has a diameter of 120 mm as shown in the diagram alongside.



(a) What is the volume of the shot put ball as shown? Round your answer to the nearest cubic centimetre.

(b) The shot put ball used in international men's competition must weigh 7260 g.

(c) The shot put ball used in international women's competition must weigh 4000 g.

If density = $\frac{\text{weight}}{\text{volume}}$, what is the density of this shot put ball, in grams per cubic centimetre correct to one decimal place?

Figure 1.

Material	Brass	Copper	Lanthanum	Lead	Silver	Vanadium
Density	8520	8940	6145	11 340	10 490	5494

Table 2. Selection of materials with their densities in kg m^{-3}.

Event	Circle diameter	Line length	Width
Discus	2.50 m	80 m	48 m
Hammer throw	2.135 m	100 m	54 m
Shot put	2.135 m	25 m	15 m

Table 3. Key specifications for discus, hammer and shot fields.

TASK ONE

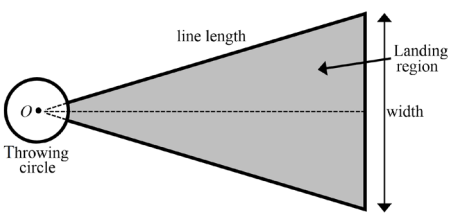
Find the limits of density, correct to two decimal places in grams per cubic centimetre, of material to form shot put balls with the required weight (7.260 kg or 4 kg) with diameters in the required range (110 – 130 mm, 95 – 110 mm)

TASK TWO

Given a list of materials and their densities, for example, in Table 2, which could be used to form shot put balls of the correct weight within the size limits for either/both of men and women?

See Engineering ToolBox (2004), for example, for a large list of metals and their densities.

Both of these tasks will require some organisation and careful thinking, and will probably take around 30 minutes to complete using a calculator. A modified form of the trial examination question here may be required as a lead in for either task.



The specifications for the field events of discus, hammer and shot put are similar. Each event has a throwing circle from which the throw is made. The fair throw landing area is defined by a pair of lines emanating from the centre of the throwing circle with an angle of 34.92° between them at the centre of the circle. Each of these events has a specified line length, and width at the end of the lines, as given in Table 3.

These event fields are similar figures, and a set of tasks based on one of these events in one year could become the basis for a similar set of tasks based on another event in a later year. Students could be given diagrams with most of the key information and be required to find the missing values (side lengths or angles), as well as areas of the defined triangles or sectors if the end of the fair throw area is made part of a circle. Given the length of a particular throw (or the world or Australian record for that event), determine the fraction (percentage)

of the field that has been covered or is yet to be covered.

If the event field is a particular orientation, then bearings may be calculated for the key lines, to locate where a particular throw (or throws) landed, or to locate where particular officials may stand given key information as in Question 3 2017 (see Figure 2).

For the hammer throw and the discus throw, the throwing circle is required to have a safety cage around it, opening out to the landing region. The IAAF specifications for each event's safety cage (IAAF, 2019) could form the basis of further problems or investigations, such the requirements for the length of framing material or the area of mesh.

The throwing circle for the shot put has some special features that can form the basis of tasks (see Figure 3).

Problem: How would the volume of the stop board be calculated?

Bearings may be calculated for foul lines or to locate where throws landed, given key information similar to Question 3, (see Figure 4).

Answers: (a) 81.40 m (b) 104°

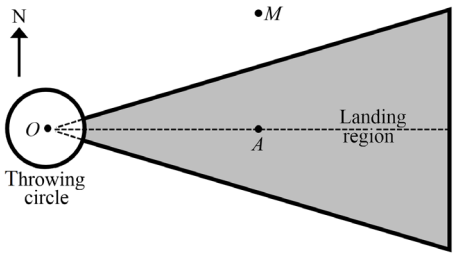
REFERENCES

Engineering ToolBox, (2004). Metals and Alloys - Densities. [online] At www.engineeringtoolbox.com/metal-alloys-densities-d_50.html

IAAF (2019) Track and Field Facilities Manual. At www.iaaf.org/about-iaaf/documents/technical

2017, Exam 2 Question 3

Michael, the chief supervisor of officials, is conducting a training session on a practice field as shown in the diagram below. The centre line of the landing region on the practice field runs due west-to-east.



Michael is currently standing at a point (marked M on the diagram above) to the north of the landing region and 30.0 m from point O (the centre of the circle). When Abebe, the chief Kenyan official, stands on the centre line of the landing region at point A which is a distance of 23.0 m from point O, Abebe is due south of Michael.
If another official stood at point O, at what bearing, correct to the nearest whole degree, would Michael be from this official?

Figure 2.

2017, Exam 2 Question 3

The throwing circle in the main arena is shown in greater detail in the diagram alongside. The centre of the circle is marked O, and its diameter is 2.135 m. At the front is a stop board (shaded grey) which the throwers are not allowed to step on or across. It is 1.20 m long. The sides of the stop board meet the circumference of the circle at points P and Q. What is the magnitude of the angle POQ? Give your answer correct to two decimal places.

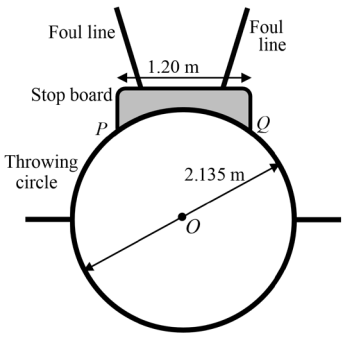


Figure 3.

2016, Exam 2 Question 3

The actual orientation of the javelin field at the Mildura Athletics Stadium is West-East.
Kai's first throw travelled 85.41 m on a bearing of 078°T.
Kai's second throw landed at a spot which was 38.00 m on a bearing of 187°T from the landing spot of his first throw.
(a) How far, in metres correct to the nearest centimetre, did Kai throw the javelin on his second throw?
(b) On what bearing, correct to the nearest whole degree, did Kai's second throw travel?

Figure 4.

MEASURING TIME

Terence Mills and Patrick Mills

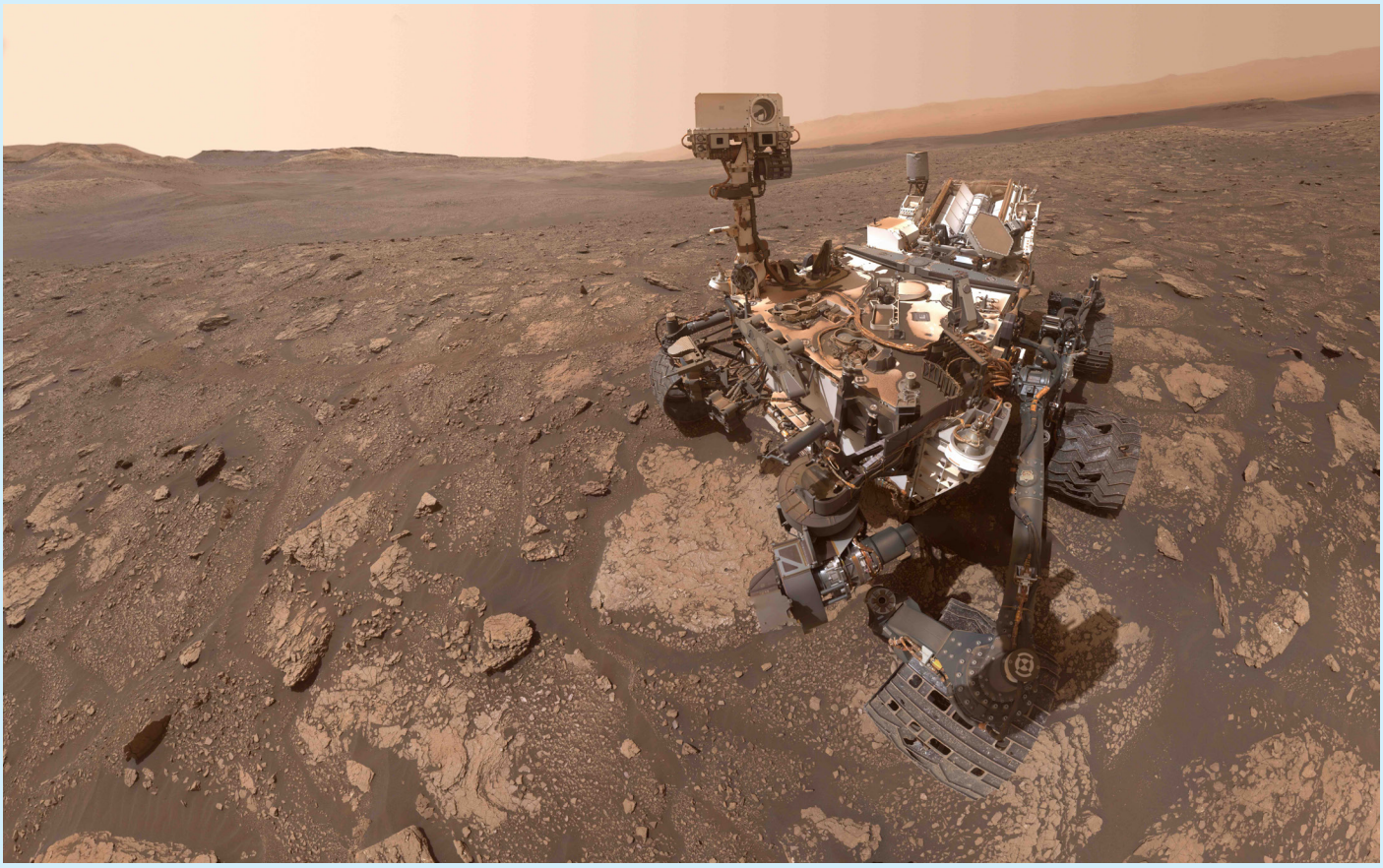


Figure 1. Curiosity rover on Mars. Image courtesy of NASA.

We might think that we have the metric system in Australia, yet there are 60 minutes in an hour, 24 hours in a day, 7 days in a week, and 12 months in a year, and the months do not have the same number of days, and let's not forget leap years and daylight saving.

The variability in the dates of Easter, Ramadan, and Chinese New Year is a mystery to many. How did we get into this mess? The answer involves history, astronomy, astrology, religion, culture, politics, and, of course, mathematics. Holford-Strevens (2005) is an authoritative, short survey.

Ever since the time of Euclid, definitions have had a fundamental place in mathematics because they form the foundations of mathematics. We can see this in the measurement of time. How could a 'day' be defined?

Most of us agree that a new day begins at the stroke of midnight. However, it might be argued that the beginning of one day and the end of the previous day is when the sun rises, or when it sets, or some other astronomical event occurs. Although the starting point for the day could be arbitrary, this question highlights the link between time and natural events. Likewise, we might ask, 'How could one define a year, or a month, or a week?' These could be interesting questions for class discussion.

In our calendar, which is known as the Gregorian calendar, the year is defined as one revolution of the Earth around the Sun and the month is based on the revolution of the Moon around the Earth. The weeks are another matter altogether: weeks can bleed into neighbouring months or years.

CULTURAL FACTORS

The recent research on calendars used by Indigenous Australians is fascinating. These calendars tend to be based on environmental variables, perhaps because we can observe local environmental events more easily than astronomical events, although these events may be connected. CSIRO (n.d.) provides some wonderful examples.

The calendars of ancient Egypt have to be inferred from records maintained over centuries. Each year started on the autumn equinox (22 September in our calendar) and had 365 days. In each year, there were 3 seasons, each season had 4 months, and each month had 30 days. Since that would come to only 360 days in the year, 5 non-working days were added in honour of 5 different gods. Although the Egyptian calendars were remarkably accurate, even scholars in ancient Egypt realised that their calendar was only an approximation, and it was modified several times (Sewell, 1963).

Many civilisations have had several calendars in operation simultaneously. One calendar would be for commerce and government, and the other for religious or cultural purposes. We still see this today in Australia. As far as our everyday life is concerned, the year starts on 1 January. For tax purposes, the financial year starts on 1 July. In the Catholic Church, the liturgical year begins on the first Sunday of Advent, which is on the fourth Sunday before Christmas.

If you have students from several different cultures or language backgrounds in your class, it would be interesting to compare the origin of the names of the days in different languages.

A CALENDAR FOR MARS

Since astronomy plays such an important role in the calendar, rethinking timekeeping and the calendar will be necessary for the colonisation of Mars. The Gregorian calendar is not suited for a Martian year lasting 669 Mars days.

In his fascinating book, *The Case for Mars*, Robert Zubrin (2011) proposes a new calendar for Mars. Reflecting on a calendar for Mars takes us back to definitions of units of time. Since Mars has two moons with very short orbital periods, a lunar definition of a month is not satisfactory. Zubrin argues that dividing the Martian year into twelve even months is unpractical. This is because the distance of Mars from the Sun varies by 19%, resulting in seasons with uneven lengths. By comparison, Earth's distance to the Sun varies by 3%. Zubrin's solution is to make months 30 degrees of the orbit of Mars instead of one twelfth of a year. The lengths of these months range from 46 to 66 days, which is a big variation. Simple sentences like 'My baby is three months old' would be hard to understand. Zubrin suggests that these months be named after the constellations that Mars passes through relative to the Sun. See Table 1. He explains how this Martian calendar corresponds to our calendar (Zubrin, 2011, p. 182).

The image of the Curiosity rover on the surface of Mars in Figure 1 shows why dust storms are a problem on Mars. According to Table 1, the dust storm season lasts from the month of Capricorn to the month of Aries.

An important part of mathematics education is to enable students to see mathematics in the wider world beyond the text book and the classroom. Measuring time and constructing calendars offer many opportunities in this direction at all year levels. Thinking about a calendar for Mars may well be useful for 21st century learners!

Month	Number of days	Selected features
Gemini	61	1st Gemini, spring equinox
Cancer	65	
Leo	66	24th Leo, Mars at aphelion
Virgo	65	1st Virgo, summer solstice
Libra	60	
Scorpius	54	
Sagittarius	50	1st Sagittarius, autumn equinox
Capricorn	47	Beginning of dust storm season
Aquarius	46	16th Aquarius, Mars at perihelion
Pisces	48	1st Pisces, winter solstice
Aries	51	End of dust storm season
Taurus	56	56th Taurus, New Year's Eve

Table 1: Martian calendar proposed by Zubrin (2011, p. 181).

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TODAY WE HAVE NO PLANS

Alicia Clarke –School maths leader, St. Mary's Primary School

This picture story book follows a family's busy week, with each page going through the activities completed each day, and ends with the family spending a lazy Sunday together.

The weekdays are busy as Mum, Dad and the children race around to school and different extra-curricular activities, each of which happens on a certain day at a certain time. The days of the week are listed in order, and there is also reference to times of day such as morning, afternoon and night. Children will relate to this story as they themselves will be familiar with many of the activities – getting ready for school, swimming lessons, sports, grocery shopping, and school days. The beautiful illustrations and rhyming text make the story very enjoyable to read and engage with!

Along with being a beautiful story to read with children, this book has a clear focus for classroom mathematics learning. It goes through each day of the week in sequence, and discusses events that happen each day. This links directly with the Victorian Curriculum, under the Measurement and Geometry strand, as below:

Victorian Curriculum Achievement Standards
Level D (Towards Foundation)
Identify the days of the week in sequence.

Foundation Level
Connect days of the week to familiar events and actions.
Compare and order the duration of events using the everyday language of time.

Level One
Describe duration using months, weeks, days and hours.

Today We Have No Plans is a great springboard for a maths sessions on days of the week and sequence of events in Foundation and Year 1 classes. Here are some activities that could be completed by students of different ages after engaging in the story.

PRE-SCHOOL

There is much research about the power of parents reading to children before they start school. Reading with and to young children is no doubt a powerful contributor to the development of Early Literacy Skills, but engaging in books such as *Today We Have No Plans* can add the element of developing early numeracy skills as well. By simply reading the story and emphasising the day of the week on each page parents can begin to introduce their pre-schoolers to the time concept of days of the week. This can be extended into everyday life by having discussions with children such as 'Today is Thursday. On Thursdays you go to Kinder' or 'It is night time so we are going to bed'.

FOUNDATION

The Victorian Curriculum indicates that students in Foundation should be able to name the days of the week in sequence, as well as connect familiar events to days of the week, for example, on Tuesdays we have our sports lesson. After reading the story *Today We Have No Plans*, the class can search through each page to find the day of the week mentioned, and list these in order on the board.

This story is readily available online and another way to do this may be to display each page of the story on the interactive whiteboard and have students physically underline the day of the week. Students can then engage in small group or independent learning tasks such as sequencing days of the week cards in order, with enabling and extending questions as listed below:

- Which day comes before Tuesday?
- Which day comes after Friday?
- Which day comes between Wednesday and Friday?

To assist students in connecting familiar events to the days on which the occur, it is helpful to have students construct a weekly timetable, where they draw something that happens on each day of the week, for example, my show and tell day is Monday, on Tuesday we have library and on Wednesday we have sport.

Another useful activity for Foundation students is to have students sort events into morning, afternoon and night (see image above). This may be slightly different for each individual student and can promote excellent discussion, for example, Tom does his homework before dinner but Sarah does her homework before school.

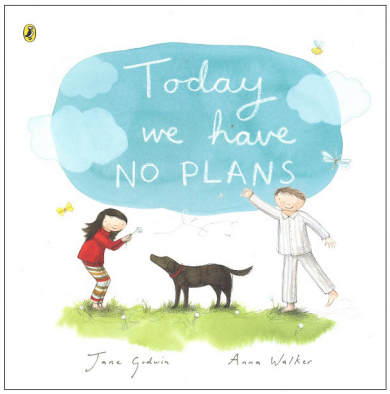
YEAR ONE

At Level One, the curriculum indicates the students now need to begin to explore time in terms of duration rather than just sequence. *Today We Have No Plans* can easily be extended to provide a springboard for students in Year 1 and above. A great example of this is to have students identify the time each event is occurring. For example, the story talks about the children having swimming lessons after school. What time might their swimming lessons be? Students can show this time on small analogue and digital clocks. A further extension may be: if the swimming lesson goes for 1 hour, what time will it finish?

A PICTURE STORY BOOK STUDY OF TIME

There are many picture story books which focus on the days of the week. Two of the better known ones are *The Very Hungry Caterpillar* and *Diary of a Wombat*.

By using *Today We Have No Plans* along with these books, an entire unit on time could be constructed, with the picture story books placing the concepts within relatable and engaging contexts for students. Sequencing the days of the week, exploring different times of day and duration of events and connecting events to days and times which they occur are all skills and concepts that can all be linked with these beautiful picture story books.



This book is available from MAV's online shop, www.mav.vic.edu.au/shop.

MATHS300

Marissa Cashmore – Mathematics education consultant and teacher at Macclesfield Primary School

Figure 1.

Maths300 is an online library of rich, open ended, inquiry-based maths tasks. There are over 200 lessons to choose from that range from Foundation to Year 12.

Maths300 lessons cover a wide range of concepts and each content area, in every year level. With clear links to the Australian Curriculum, multiple skills and strategies across many concept areas of mathematics and cross curricular connections, are covered within one task. Tasks I have used, such as *Potato Olympics* and *A Snail's Holiday* incorporate science, literacy, and technology.

Let me share a favourite lesson I've used to teach algebra to Year 4, 5 and 6 students.

LESSON #016 GARDEN BEDS

Garden beds can be introduced in a variety of ways, acting out, modelling and visual representations. It is a brilliant lesson to introduce and develop students understanding of algebra.

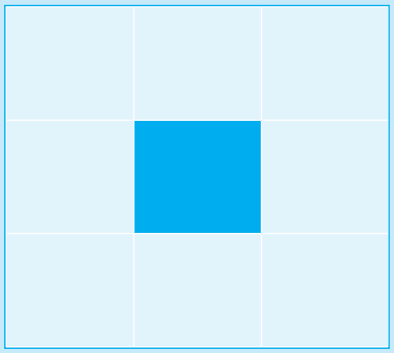
I start the task with a story shell: 'I was a very lucky girl growing up, I had a caring, generous and funny grandad, who I got to spend a lot of time with. In fact, he spoilt us rotten! He would take us to the shops, and always buy us a bucket of chips, or walk us down to the library to feed the ducks in the pond. Everyone adored him. My grandad also loved gardening, but he was constantly in battle with the snails when his vegetable patch started to grow.

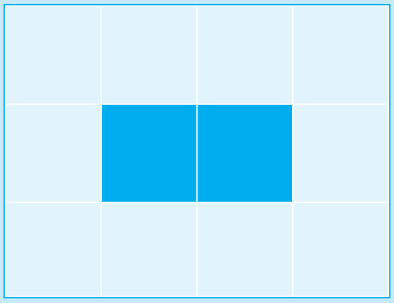
In his memory, I would like to create a vegetable garden. I've found some awesome tiles that have a snail repellent finish on them to keep the snails away. I was wondering if you could help me to work out how many tiles, I need to create my garden.'

Giving the students an insight into who my grandad was and how important he was to me, allowed my students to enter the task and become invested and connected to the problem.

With the students in a gallery style circle and large paper tiles in the centre, students start visualising what the garden beds might look like. Students are invited to come forward to start creating them.

For one garden bed, how many tiles are needed? What about for two garden beds?





Emphasising the importance of making sure the snails cannot get in, eventually the students start to visually see the growth in the tiles.

The lesson continues and the students work on solving the problem. How many tiles would be needed for 8 garden beds, 15 and so on building and recording a visual (and perhaps written) patterns and trying to work out what the algebraic rule is.

WHY CHOOSE MATHS300?

I was introduced to Maths 300 through a colleague demonstrating a lesson called *Number Charts*, he used a story shell to introduce this lesson to the students. 'I was in a doctor's waiting room, flicking through the magazines, when I came across a puzzle that looked like a smaller version of Figure 1. But, I can't remember how to solve it!?' he said, scratching his head and frowning. The students surrounded the giant puzzle and they were hooked! This was the day I began my love affair with Maths300.

It is the go-to resource of rich maths tasks. Students are highly engaged and keen to challenge themselves and their learning to solve problems that they may not have been comfortable attempting before. Each student can access the hands on, visual approaches to Maths300 lessons as each task has multiple entry and exit points, allowing for differentiation. AAMT are working on producing a new browser based platform, with 10 new lessons added to the library of well-loved, tried and tested Maths300 tasks.

For more information about maths300, trial lessons and access to professional learning go to https://maths300.com/

INVESTIGATIONS

Ellen Corovic, Jennifer Bowden, Helen Haralambous and Danijela Draskovic – Education consultants, Mathematical Association of Victoria

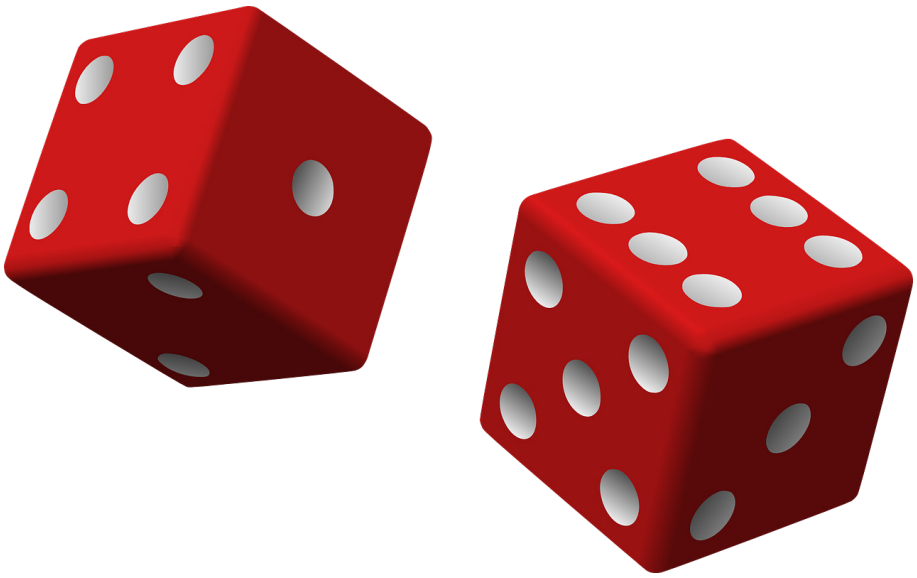
FOUNDATION - YEAR 2

MAKING COLLECTIONS

Either roll two dice or turn over two playing cards (e.g. 5 and 3) and use the two digits to make a two-digit number (e.g. 53). If you don't have either of these make up your own numbers. Make a collection of your two-digit number using things in your home. Arrange the collection to make it easier for you or someone else to count.

Draw a number line with 0 as the lowest number and 100 as the highest number, record where your two-digit number would sit. Create a new two-digit number and repeat the steps above.

Extending prompt: create a three-digit number.



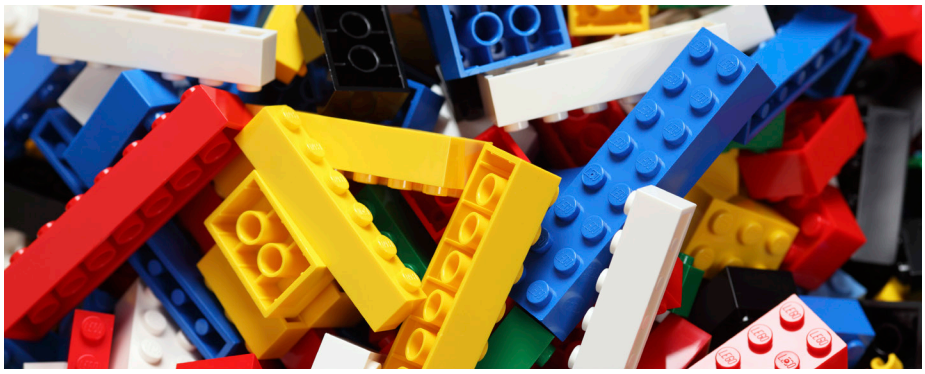
YEAR 3 - YEAR 6

QUANTITY OF NUMBERS

Find at least three things in your home that you have the following quantity of:

- 10
- 100
- 1000
- 10,000
- 100,000
- 1,000,000

Some examples are: chairs, socks, lego pieces, grains of rice, blades of grass.



YEAR 7 - YEAR 9

CLOSE TO BEING WHOLE

Adapted from Nrich

- Choose fractions from this list, you can choose as many as you want but cannot repeat a fraction.
- Without using a calculator, add the fraction you chose. Can you get close to 1? Which selection of fractions, when added, will give you the closest total to 1?
- Now use any of the four operations: + - × ÷, does that help you get closer to 1?

$\frac{1}{6}$	$\frac{1}{25}$	$\frac{3}{5}$
$\frac{3}{20}$	$\frac{4}{15}$	$\frac{5}{8}$

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MAV SACS 2021 materials have been written by experienced VCE mathematics teachers. They are for use by teachers to aid in assessment of student School Assessed Coursework for Further, Methods and Specialist Mathematics.

PLEASE NOTE: this resource is only available to current practising Victorian secondary teachers. The product is for school use only. It is not to be used by private tutoring services.

INDIVIDUAL STUDY — $54.50 (MEMBER) $68 (NON MEMBER)

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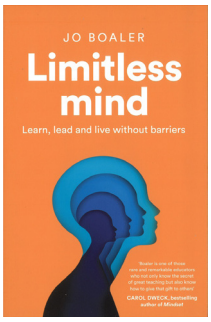

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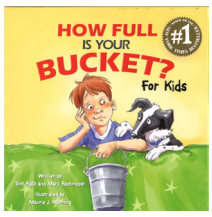

HOW FULL IS YOUR BUCKET?

2–6

Each of us has an invisible bucket. When our bucket is full, we feel great. When it's empty, we feel awful. Yet most children (and many adults) don't realise the importance of having a full bucket throughout the day. In this book, Felix begins to see how every interaction either fills or empties his bucket. Felix realises that everything he says or does to other people fills or empties their buckets as well. Follow Felix as he learns how easy it can be to fill the buckets of his classmates, teachers and family members. You'll see how Felix learns to be a great bucket filler, and discovers that filling someone else's bucket also fills his own.

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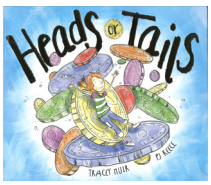

HEADS OR TAILS

1–6

When Maggie can't decide what to do, she flips a coin - but not all the results come out in Maggie's favour. What will Maggie do when she has a really important decision to make?

Can you guess what happens next?

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