THE MATHEMATICAL ASSOCIATION OF VICTORIA

THE COMMON DENOMINATOR 2/17

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CHANGING THE WAY GIRLS SEE MATHS

How many times have you heard the words 'I'm not good at maths' or 'I never got maths'? It goes on and on from students, teachers and parents who often gave up on mathematics sometime during their schooling. And it is not just maths, but anything maths related. I get the same statements from students in their first year science degree even after they have successfully completed first year physics and maths and particularly from female students.

The reasons for these comments are often due to the ideas that maths is an innate ability and girls are unlikely to have this ability because of their gender. That these ideas continue to flourish despite the current research is frustrating as an educationalist, but why do these ideas persist and how can we make changes?

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

Magazine 262, April 2017

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Print Post Approved
Publication No: PP100002988

FROM THE PRESIDENT

Jim Spithill - ACER

I chanced upon a book that gives a historical overview of the development of mathematics education in England since the 16th century. It seems there is something universal about the challenges we face, from political pressures, to providing for a skilled workforce, to maintaining a well-trained cohort of mathematics educators.

A text book question from 1543 has a political edge in mocking the clergy: 'There is in a cathedrall churche 20 cannones, and 30 vicars, those may spend by yeare, £2600 but every cannon muste have to his part 5 tymes so much as every vicar hath: how much is every mans portion saie you?' In 1581 Richard Mulcaster wrote: 'The Mathematical Sciences ... show themselves in many professions and trades ... whereby it is well seen that they are really profitable; they do not make an outward show, but our daily life benefits greatly by them'. In 1662, aged 29, Samuel Pepys wrote: 'Up by 4-aclock and hard at my multiplication table which I am now almost master of', at a point where his days were spent working at the Admiralty and realising that the Navy as a whole was handicapped by a lack of mathematical expertise. In fact it was the military need for navigators and engineers that drove the expansion of mathematical training.

At MAV's annual conference in 2015, I attended a very thoughtful presentation by Dr Jude Ocean (RMIT) in which she explored the persistence of the military model even today: '... about the ways in which 'traditional' mathematics education is military in style ... eight maths classroom practices that reflect a military agenda: silence, watchfulness, rules, commands, obedience, competition, testing, and streaming'.

By early in the 19th century there was political recognition of the need to extend educational opportunities to the 'poor'. Augustus De Morgan wrote: '... schools cannot expect to make learned men; but they may make good learners ... and produce such a desire for knowledge as shall lead the individual to devote himself to study where it is not a matter of compulsion'. De Morgan was the inaugural President of the London Mathematical Society, in 1865. Our very own MAV became a colonial version 108 years ago.

In the first decade of the 20th century a young Elizabeth Larby studied in a special 'scholarship class'. Even then it was well known that: 'opportunities varied considerably throughout the country, and selection was clearly shown to depend more on social factors than academic ability'. She was successful and, as Elizabeth Williams, went on to a flourishing career in mathematics education, doing much to improve the training of teachers of mathematics.

Which brings us to 2017. The questions and challenges in mathematics education remain much the same. The answers and responses vary from one school to another depending on local circumstances and resources. The MAV stands ready to assist teachers and schools along the pathway of continuous improvement.

REFERENCES

Howson, Geoffrey (1982). *A history of mathematics education in England*, Cambridge University Press.

NIGHT AT THE MUSEUM

JOIN THE MAV FOR A NIGHT AT THE (SPORTS) MUSEUM

Tuesday 16 May, 6pm – 8pm

Join us for the launch of our new *Made By Maths* app, developed in conjunction with the National Sports Museum. Hear from the app developers and the exhibition curator, with a short break for our AGM, before drinks and nibbles and the opportunity to explore the museum and try out the app for yourself.

Numbers are strictly limited – attendance is free, but registration is essential, call 9380 2399 or email office@mav.vic.edu.au.

PROFESSIONAL DEVELOPMENT

During Term 2 and early Term 3, 2017 a variety of presenters and MAV's own mathematics educational consultants will present workshops focussing on innovative teaching practice.
Make sure you reserve a place by booking online early, www.mav.vic.edu.au/pd.

TOPIC	DATE	YEARS	PRESENTER
Making confident maths teachers - Ratio, proportion and percentages	29/4/17	7-10	Ian Lowe
Hands-on algebra	2/5/17	7-10	Helen Haralambous
Algorithmic thinking, flowcharts and coding in transition years	May - TBC	5-8	Martin Buchholtz
Meet the assessors: Further Maths - Terang	3/5/17	VCE	Peter Jones
Meet the assessors: Maths Methods - Terang	3/5/17	VCE	Rod Watson
Making confident maths teachers - linear functions, graphs and equations	13/5/17	7-10	Ian Lowe
Making confident maths teachers - integers, linear and quadratic expanding and factorising	27/5/17	7-10	Ian Lowe
Understanding sampling distributions and hypothesis testing: Specialist Maths	31/5/17	VCE	Susan James
Develop a meaningful mathematics program	22/7/17	F-6	Paul Swan

If you'd like tailored professional development, contact Jen Bowden, jbowden@mav.vic.edu.au.

MATHS ACTIVE SCHOOLS

Is your school doing amazing things in the area of mathematics education?

MAV's Maths Active School accreditation is a great way to showcase your schools' effective mathematics teaching and learning programs. To be accredited, schools must complete an application that will be reviewed by the MAV's team of mathematical education consultants and the MAV Council.

Visit www.mav.vic.edu.au to get more information about the program and details on how to apply or contact Ellen Corovic ecorovic@mav.vic.edu.au or 9380 2399.

DEVELOPING A MEANINGFUL MATHEMATICS PROGRAM AT YOUR SCHOOL

Teachers from MAV's Mathematics Active Schools are able to attend a free professional development workshop with Dr Paul Swan at Fintona Girls' School on 25 July 2017.

Dr Paul Swan will equip you with the knowledge and skills to develop a meaningful mathematics program within your teaching context. During this hands-on workshop, you will be equipped with games, activities, planning documents, examples of materials and assessment techniques.

The workshop will focus on:

- worded questions, their presence in national testing
- understanding and application of the mathematics involved
- broadening the problem solving process so that it becomes a natural part of the lesson
- mathematics behind engaging games and links to the Australian Curriculum
- developing fluency by linking the proficiencies.

If you are a teacher at one of MAV's Mathematics Active Schools and would like to attend this workshop, email Jacqui Diamond, jdiamond@mav.vic.edu.au.

THE MATHEMATICAL ASSOCIATION OF VICTORIA | MATHS ACTIVE ACCREDITATION

GIRLS IN STEM (CONT FROM PAGE 1.)

Jacinta den Besten - School of Physics, University of Melbourne

Why girls are not taking up STEM subjects and careers at the same rate as their male counterparts is a very complex and nuanced problem. I want to briefly touch on just three reasons in this article and ways we can work towards changing this.

The topics require much more justice than I give them here, but hopefully the resources listed will start you on your own exploration on the subject.

MYTH 1: GIRLS DO NOT PERFORM AS WELL AS BOYS IN MATHS.

When you remove race and gender equity circumstances, girls perform just as well as boys in maths as reported in the latest PISA studies. The evidence now points towards gender bias and cultural, societal settings as to why girls have been underperforming. Dr Cordelia Fine examines the impact of gender bias in her book *Delusions of Gender*.

That the misconceptions of perceived gender ability have made such an impact on the performance of girls and women for so long is extremely troubling. That we have until this century put all our scientific efforts into seemingly justifying this difference rather than addressing it is equally troubling. Yet now we are beginning to understand just how much this way of thinking has restricted the choices of all our students, but especially girls undertaking STEM. In talking to young girls about the STEM issues and gender bias, it has been fabulous to hear their understanding of the issues and a shift in their self-belief and abilities.

So what can we do?

- Change the language we use with our boys and girls, just as girls can be equally able in maths and science, boys can also be great readers and empathisers. Let them know this and have expectations that they will be so.
- Teachers, parents and students can undertake unconscious bias training.
- Encourage parents (mums and dads) to learn with their students when helping with maths homework rather than use the statements I opened with!

MYTH 2: THE BRAIN STOPS DEVELOPING AFTER AGE 7

The brain is highly malleable and the phrase 'you can't teach an old dog new tricks' just doesn't fly anymore. The idea that our brains are hardwired from our days as cave men and women has been challenged time and again. As educators we have always known this as we have spent our lives as life-long learners. Dr Carol Dweck and colleagues have shown that the language we use to encourage and congratulate our students has a significant influence on their mindset. Students either see mathematics as an innate ability, one they are born with, hence a fixed mindset or an acquired ability, something they can work hard to improve in, hence a growth mindset. What startled Dweck and her team was the clear correlation of girls more likely having a fixed mindset and boys the growth mindset. Further work with Jo Bohler, demonstrated that this was particularly evident in maths-based subjects.

So what can we do?

- Help students to change their mindset towards a growth mindset. Celebrating mistakes as a learning opportunity rather than the expectation of getting everything correct. Learning to take risks.
- There are many simple online and paper tests for understanding a student's mindset.
- A real life role model is incredibly powerful for changing a fixed mindset and challenging a stereotype.

MYTH 3: BOYS ARE LOGICAL THINKERS, WHERE AS GIRLS ARE EMOTIVE AND CREATIVE

Prof Sheryl Sorby, an engineering educator in the US, wanted to find out why her female students rarely continued their degree after the first year. Upon surveying the students who weren't doing well, they all expressed a lack of confidence in their spatial skills. Incorporating a simple 10 hour introductory course in spatial awareness, playing with construction toys, working in 3D problems, using 3D software, she now has a much greater retention rate for both male and females.

So what can we do?

- Understand your student's skills with spatial awareness/reasoning testing.
- Pull out the LEGO®, let them loose on Google Maps and explore 3D CAD software such as TinkerCAD.
- Games such as Tangram and Minecraft.

The research results above demonstrate that with the appropriate opportunities, we all have the ability to learn new concepts and skills, that we can change our mindset and that gender does not need to be a factor in our learning. John Hattie (Visible Learning) has also demonstrated that teaching according to gender has very little influence on student outcomes. Coupled with Fine and Dweck's research, changing community expectations and bias can result in huge changes in a student's self-efficacy.

REFERENCES AND RESOURCES

PISA(Programme for International Student Assessment) OECD (2017), Mathematics performance (PISA) (indicator). doi: 10.1787/04711c74-en (Accessed on 05 March 2017) https://data.oecd.org/pisa/mathematics-performance-pisa.htm

Fine, C. *Delusions of Gender* , W. W. Norton & Company (2010)

Boaler, J., *Mathematical Mindset*, John Wiley and Sons Ltd (2015)

Dweck, C. *Mindset*, Little, Brown Book Group (2006)

Mindset Quizzes, https://www.mindsetworks.com/assess/ (Mindset Works)

www.edpartnerships.org/sites/default/files/events/2016/02/Mindset%20Quiz.pdf

Sorby, S. Educational Research in Developing 3-D Spatial Skills for Engineering Students, *International Journal of Science Education*, Vol. 31, No. 3, pp. 459 - 480, 2009

Spatial Reasoning test: www.123test.com/spatial-reasoning-test/

TinkerCAD: www.tinkercad.com

Minecraft: https://minecraft.net/en-us/

Hattie, J. *Visible Learning for Mathematics*, Corwin (2016)

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SOAK UP MATHS THIS SUMMER

NATIONAL MATHEMATICS SUMMER SCHOOL (NMSS)

CANBERRA, 7–20 JANUARY 2018

Being awarded a place at this summer school gives students who love mathematics an opportunity to have fun together as they discuss and explore mathematics from some very different perspectives.

Give your students who love mathematics a chance to apply. Generally only one or two applicants from each school are selected, so this increases the number of schools participating which adds to the richness of the summer school experience. Students from all over Australia who are in Year 11 in 2017 can apply.

The summer school is a two-week program held at the Australian National University in Canberra in January 2018. Many enduring friendships are made on this very special summer school, now in its 50th year. Each year, a few past students return to help run the program which is testament to the value they place on their summer school experience.

There is a strong emphasis on solving problems and many students often find themselves working on problems well into the night (because they want to)! There is also an emphasis on recreation, exploration and fun and many activities, tours and talks are organised. During afternoon recreation, students are free to socialise and explore Canberra (popular activities include ice skating, ten pin bowling, tandem bike riding around the lake). There is an entertaining dinner and concert on the last night.

Selection is based on the strength of a student's written application, a teacher reference, and the creativity and perseverance shown on a problem solving test which includes some unfamiliar problem solving questions that do not require higher level mathematics to solve them (just creative use of simpler mathematical ideas), and some questions that require algebraic proof, and use of other higher-level mathematics in unfamiliar ways. There is no requirement to be able to do all types of questions to demonstrate the ability to think creatively with mathematical ideas. Being able to use mathematics creatively is what is highly valued.

The NMSS student contribution for NMSS 2018 has not yet been set. To give you an idea, it was $1100 for NMSS 2017 with a travel surcharge if students/parents want NMSS to organise return travel from Melbourne airport. The amount is expected to be more for NMSS 2018. The closing date for applications is 28 July 2017 and the 90-minute selection MAV Test for NMSS will be held on 4 August 2017 at the applicant's school.

Applications are now open. Visit www.nmss.edu.au for more information.

MAV17 CONFERENCE

Achieving excellence in M.A.T.H.S | 7 - 8 Dec 2017

WHAT DOES EXCELLENCE LOOK LIKE?

Results have indicated that Australia's international standing in mathematics is slipping, a problem that all parties need to address. We need to consider the results, and more importantly share what is really working well in Victorian schools. Victorian schools continue to perform above the OECD average and at the upper end of results across Australia.

The MAV is dedicated to the improvement of mathematics education and at this year's annual conference delegates will investigate the most effective approaches, tools and new technology, that education professionals can use to improve student learning outcomes.

At MAV17, learn first-hand about the latest developments in mathematics education and be inspired by the wide-range of sessions available. Network with primary, secondary and tertiary teachers; teacher educators, researchers and academics; resource providers and representatives from government and other education bodies.

Don't miss out on this invaluable opportunity at MAV17 to share and discuss excellence in maths while making social and professional connections in a dynamic environment.

The conference will be held at La Trobe University, Bundoora campus, 7-8 December 2017.

CALL FOR OPTIONS IS OPEN!

MAV17 conference call for options is open. This year we are asking for submissions from education experts who want to join us in exploring the question, *What does excellence look like?* This is a chance for you to share your experiences and knowledge with your colleagues.

Closing date for options is Friday 30 June 2017.
For more information visit the website www.mav.vic.edu.au/conference or contact Jacqui Diamond, jdiamond@mav.vic.edu.au.

Keynotes and interactive sessions will focus on five themes.

M

Mindsets
Developing growth mindsets in the classroom, amongst educators, and at a school and policy level. Identifying best practice across these sectors to support students to have a healthy approach to learning mathematics. Promoting that maths is fun and that everyone can do it, and valuing mathematics in society.

A

Assessing
An integral part of teaching and learning. Providing opportunities and tools for educators to identify areas of strength and weakness and to diagnose common misunderstandings.
Investigating NAPLAN and other standardised testing, and how it can help inform local practice and policy.

T

Targeting
Targeted approaches to create and embed deeper understanding by developing new pedagogy and exploring comprehensive resources to equip educators on all aspects of the mathematics curriculum. Using diagnostic tools to deliver personalised learning experiences and content to students.

H

Hands-on
Innovation in online learning, technology and STEM. Interactive educational games, engaging and rich tasks, online learning, and activities for learning enhancement. Focussing on 21st century skills and capabilities including problem solving, mathematical communication, creativity, innovation and critical thinking. Purpose, place and role of models and modelling in mathematics. Investigate pedagogy in the classroom and how modelling can be used to help students learn.

S

Shifting the narrative
Move away from 'how bad the results are' and capitalise on what is working well in Victorian schools. Working collectively to improve student achievement through evidence- based approaches at all levels of the system: teachers, schools, school leadership, government, parents and students. Working in learning partnerships.

TEACHING YEAR LEVEL MATHS

Rhonda Faragher - University of Queensland

Group work in a lesson on fractions.

LEARNING YEAR LEVEL MATHEMATICS CURRICULM WHEN YOU ARE YEARS BEHIND

Teachers in the upper primary years and higher are familiar with students who are years behind their classmates in their maths attainment.

Planning the learning for these students presents a considerable dilemma. Do we go back and reteach work from years below in the curriculum for one student while teaching another lesson to the others? Do we move to a 'functional' maths program? Is there a better way?

I have a daughter with Down syndrome and as she moved into secondary school, this challenge presented itself when her maths teacher was faced with a student who could not reliably give the answer to single digit additions. Her teacher was prepared to develop lessons for my daughter to reteach the basic arithmetic from Year 2 as well as plan for her regular Year 8 class. Laudable but unsustainable. Not only would her teacher face double the work, there was every chance she would be no more successful than the excellent teachers before her who had tried to teach my daughter arithmetic.

Instead, we talked about a radical approach that had been tried with success in Italy and the US – teaching year level curriculum with modifications. My colleague is a courageous soul and was willing to give it a try. The next topic on the program for the Year 8s was percentages – certainly not the easiest unit in the year and yet, in just three weeks, my daughter was completing exercises such as finding the percentage of a number. To do this, she needed the support of a calculator to do the arithmetic which she could not. Her teacher taught her to use the fraction and fraction to decimal keys along with careful step-by-step explanation of the procedure. Understanding and fluency were the goals of this lesson for all the students and my daughter was able to meet these learning objectives.

Some years on, there is now a growing collection of case examples where students who are similarly many years behind their class peers (for many reasons – poverty, absence from school, intellectual disability etc.) have made remarkable progress when taught the year level curriculum.

At least two questions are raised by teachers: how is this done and should we even do this in the first place.

HOW TO PLAN AND TEACH YEAR LEVEL MATHEMATICS

Jerome Bruner in his seminal work, *The Process of Education*, claimed 'any subject can be taught effectively in some intellectually honest form to any child at any stage of development' (1960, p.33). Teaching year level mathematics curriculum, though seemingly counter-intuitive, has its basis firmly in established educational theory.

Start with the curriculum for the year level.

Planning year level curriculum begins as you always would. Building on the requirements of the Australian Curriculum, system and school plans, the content and proficiencies are established. This is the point of clarification of the topic area – knowing what has to be taught to all the students and ideas for how this might take place. This is the standard teaching preparation.

Seek guidance about specific learning issues. Work with specialist teachers (where available).

For some students, there are specific learning issues for the student that benefit from specialist input. This could be provided by special education support such as through disability support groups. If the student has a learning support plan, there is likely to be information about effective teaching strategies there.

Explicitly plan adjustments. Provide direction to teaching assistants.

The step of explicitly planning adjustments is one of the places where teachers can be creative. When we are teaching techniques, it is part of a maths teacher's repertoire to know how to break examples into small steps. In special education, this is known as task analysis. For learners who may have trouble remembering the steps in a process, they can be written on a card and kept for the student to consult. One teacher had these laminated on coloured card and used a split ring to keep them together.

The student carried the cards in his pencil case. An example is shown below.

SINE RATIO
Write down the rule:
Sine θ = opposite side ÷ hypotenuse side
Write in the numbers:
Sine θ = (____ ÷ ____)
Use your calculator to work out the answer for Sine θ :

Use your calculator to find θ :
ANS Shift $\sin^{-1}$

Other adjustments could be the use of visuals. These might be diagrams, concrete materials, mathematics symbols (carefully explained), timelines, hundreds charts, … Notice that these are familiar supports available in any maths classroom. Rarely are materials so specialised (such as Braille) that they are only of use to students with specific disabilities.

Calculating devices (calculators, iPad apps, spreadsheets etc.) are usually essential and their use needs to be explicitly taught. Unless the objective of the lesson is mental computation, calculators should be readily available.

Working on a scale drawing assignment in Year 6 mathematics.

Providing direction to teaching assistants (TA) is essential. Learning adjustments is skilled, professional work requiring the expertise of a qualified teacher. It is important for the TA to be told the mathematical purpose of a lesson. I observed a lesson on data display where the task was to draw a bar graph. The TA thought the key point was to complete the task so she did all the measuring work and left only the ruling of the line along the top of the bar for the student. The mathematics had been removed altogether. The teacher noticed the problem and quickly redirected the TA to guide the student to measure the length of the bars using the scale.

Provide opportunities for consolidation and practice.

Opportunities for consolidation and practice are important for all learners but essential for students where learning might be unstable. The key concepts are what need to be reinforced. The 'little bit often' rule is very helpful as a guide.

Assess learners throughout the learning process (not just at the end).

Tests are not the most helpful way to document what students know or can do in mathematics. They are efficient ways to gather data on large numbers of students at the one time but when that is not the goal, other approaches are more effective. Work samples, short video recordings, anecdotal notes and other 'in the moment' records provide valuable evidence of learning.

WHY SHOULD WE DO THIS?

Teaching year level mathematics content has been shown to be possible and learners with large gaps in previously believed to be pre-requisite concepts can achieve learning outcomes with their class peers.

All the same, many teachers have questioned whether other mathematics should be taught, particularly functional mathematics. The problem with determining inclusions in a functional mathematics program is that the use of arithmetic in life contexts is rapidly changing and shrinking.

In a world where the use of cash is disappearing and being replaced by PayWave, transport card systems and funds transfer, routine arithmetic is no longer necessary or sufficient. Concepts of mathematics and other disciplines that lead to financial literacy are the new essentials.

Similar arguments arise in other areas of numeracy – the application of mathematics in life contexts. It is critical that students in school are taught as much mathematics as they can in order that they will have those concepts available to be taught how to apply them in life contexts where they are needed.

Dr Rhonda Faragher has experience and expertise in mathematics education and disability studies. Her research interests have focussed on learners who find mathematics difficult, through disability or socio-economic disadvantage. Rhonda delivered a keynote on learning year level maths when you're years behind at MAV's 2016 annual conference.

MAV's annual conference is a terrific way to enhance your professional development and hear from leaders in the mathematics education sector on a variety of topics. To learn more about the upcoming conference, MAV17, visit www.mav.vic.edu.au/conference.

TRAVELLING AUSTRALIA

Maria Harkins - Year 6 teacher, St Paul's Anglican Grammar School, Traralgon

USING MATHS TO GET AROUND THE COUNTRY

Teachers can often struggle to get all that is required of them completed in one year. Here is an idea of a way to get lots done all at once, provide an interesting task over the entire term and have valuable knowledge at the end.

1. Ask your students to find a car in which they would like to travel around Australia – it can be real or perhaps they could invent their dream car. Students need to draw a car.
2. Each student needs to select a place to begin their travel in Australia. Ensure that the children do not all start in the same place (I've found that if they start at the same point, they tend to travel to the same places).
3. Each week the student can travel up to 300km. When they arrive at their destination, they must write a short paragraph introducing the place.
4. Find a place to stay and explain what is included in the accommodation for the price.
5. Find three places that are worth visiting (including costs associated with entry etc).
6. The student has to be able to show on a map where they have travelled – distance, direction, time taken and so on to give them an idea of time and distance. Discussion is often had regarding a shorter road taking longer time than a freeway or highway.

Children begin to gain more awareness of the top end of Australia and the difficulty of finding a place to stay with in 300km. Students also start to gain a true awareness of distance. Discussion is great!

Each week, the student moves from one place to another, noting their travel from one week to the next. By the end of the term, they will have at least 10 travel amounts and places that they have stayed.

Whilst there have been mathematical questions along the way, there have also been questions relating to science, history, humanities and English.

Students should be given the opportunity to present an interesting piece of information from their travels that week. This helps with the speaking and listening component of the curriculum. I have also thrown in questions about the type of fuel that is available in the outback and why. I have had students actually go on holiday with their families and have gone to the places they have researched to see if what they learnt was really there.

SO…WHERE IS THE MATHS?

Apart from the maths reading and kilometres travelled, now you can begin the really intensive maths application of the maths skills.

1. Graph the travel times and/or the distances travelled each week.
2. Find the average distance travelled for the class per week and/or the total travelled for the individual student.
3. Calculate the amount of time spent on the road.
4. Calculate the amount of money spent on accommodation - rank the places from most expensive to least and see if there is a correlation between the places and the costs.
5. Calculate the cost of the entertainment that was noted (tourist attractions).
6. Research the population of the places visited and calculate the percentage of the population of Australia or the states where the places are found.
7. Either research information from the internet (if available) or give the children information regarding the price of fuel in different states or regions and ask them to calculate the cost per kilometre.
8. Plot on map the price of fuel in the travelled area – discuss why the prices might vary.

Once you have the data, the mathematics is endless. You could even extend it to the price of cars and value for money regarding fuel consumption for those higher order thinkers.

MY BEST LESSON EVER

Joseph Wright - author of Maths Mate and founder of sQuizya

What is the best mathematics lesson you have ever presented? For me, it was a lesson I developed after reading an article in *Scientific American* written by Michael Gardner in the early 1980's. This particular article was based on research conducted by Robert Axelrod at the University of Michigan, which in turn was based on a problem known as the Prisoner's Dilemma.

This lesson appeals to me because it works on so many levels. It demonstrates how mathematics as a tool used to model and understand our world. It integrates mathematics, the arts, psychology, biology and commerce and gives students a sense of being mathematicians rather than scholars by focusing on the purpose of the mathematics rather than the mathematical process. The open-ended activities are easy to understand, but at the same time challenge each student's thinking and creativity.

When Axelrod published his research paper he probably had little idea of the extent of the ongoing research he would inspire and the hundreds of doctorates that would be awarded in the process. Why? Because the conundrum that is central to the lesson is experienced by all of us on a day-to-day basis. What's more, 37 years after the initial research, it is still possible that a student participating in this lesson will make a discovery of significant proportions.

The book, *The Origins of Virtue: Human Instincts and the Evolution of Cooperation*, by Matt Ridley is one of the many works to come out of Axelrod's research. He recounts the tale of Tosca, the heroine of Puccini's opera. Tosca is faced with a terrible dilemma - Scarpia, the chief of police has offered her a deal: if she gives herself to him, her imprisoned lover, Cavaradossi, will be spared execution. Tosca agrees to the blackmail only to stab Scarpia to death once he has given the order to substitute blanks for the live ammunition. However Scarpia had already chosen to deceive rather than co-operate: under instructions given by him in secret, the firing squad does not use blanks and Cavaradossi dies. A distraught Tosca then kills herself.

Had Tosca and Scarpia co-operated Tosca would have saved her lover's life and Scarpia would have satisfied his lust.

But each benefit more if he or she can deceive the other into keeping their word whilst not doing so themselves. Tosca would have saved her lover and kept her virtue; Scarpia would have satisfied his urges and ridden himself of his enemy.

What's interesting is that in single encounters of the Prisoner's Dilemma, the outcome is usually driven by selfishness and distrust. Players are usually encouraged to defect and deceive out of self-interest; just like Tosca and Scarpia tried and failed to do. However, the outcome is entirely different where the game can be played more than once. Game theorists such as Axelrod found that frequent repetition of an encounter encouraged cooperation. With 'the shadow of the future' held over each player the likelihood of cooperation greatly increases.

Iterative examples of the Prisoner's Dilemma abound within human transactions of a social and business nature. Examples in the animal world are also numerous. Small fish clean the parasites from sharks but surely for a shark to eat one or two of those little fish wouldn't make much difference. Fig wasps limit the number of eggs they lay in a fig tree, otherwise, the trees would suffer, but why shouldn't any one fig wasp cheat and leave a few more eggs than her rivals? Why shouldn't a villager that shares a common but finite resource try to exploit it more than the others? Sharks, fig wasps, and villagers all cooperate but scientists have struggled to explain how such cooperation evolves in a world where self-maximising behavior is supposed to dominate.

Axelrod used what is essentially a very simple idea to analyse such interactions. Using a branch of mathematics called game theory, he affixed a scoring system to a simple transaction and challenged the world at large to come up with the ultimate *Rule of Life*. The winning rule would be the rule that determines when to co-operate and when to default in a way that maximises the player's score.

The business transaction scenario used by Axelrod pitted a potato farmer against a wholesaler. The farmer has two choices. Cooperate by sending his best produce, well presented, on time and in good order. Or, deceive the wholesaler by sending the gardens lowest quality potatoes, poorly presented and only after supplying other customers. The wholesaler also has two choices. Cooperate by only adding a small margin, displaying the potatoes favourably and paying in a timely manner. Or, deceive the farmer by placing a high margin on the produce, not promoting their sale and being slow to pay.

The scoring system was as follows: Mutual co-operation earned three points per player. A defaulting player would earn five points to zero against a cooperative player with a presumption that deceiving comes at a cost. (The number of potatoes sold will be reduced so there is less money in the game.) When both sides default there is no gain to either player, but losses are minimal so each team obtains one point.

	Player A	Player B	
3 points	Co-operate	Co-operate	3 points
0 points	Co-operate	Default	5 points
5 points	Default	Co-operate	0 points
1 point	Default	Default	1 point

Scoring system for trades between two players.

This lesson recreates Axelrod's challenge in your classroom. There is no need for any coding experience, although it can be run using spreadsheets if you wish to add coding to your list of valuable outcomes from this lesson.

To familiarise the students with the scoring system I first ran a one-off competition. Each student was required to move around the room conducting a single deal with twenty different students.

In preparation, students were asked to calculate the range of individual scores possible and to find the highest possible value of the average score. I then revealed the following scoring grid that equates scores to a lifestyle commensurate with the income represented by those scores:

Score	Lifestyle
0-20	Abject poverty
21-35	Living below the poverty line
36-55	Comfortable existence
56-70	Wealthy
71-100	Very to extremely wealthy

Lifestyle outcomes based on 20 trades.

You have probably already noted that it is possible for the entire class to cooperate with each other every time leading to all members scoring 60 points and being declared wealthy. This was pointed out to the students along with a reminder that this is just a game and behaviour exhibited during the game does not represent the normal behaviour of any student!

A typical individual score sheet might look like table 1 (opposite page).

As hinted earlier in this article, deceit tends to prevail making poverty commonplace!

After this introductory activity the students were given the instructions for the main tournament. Each team of two or three students would be tasked with creating a *Rule of Life* that would be pitted against the other nine teams in the class and against itself. Each battle would be conducted over twenty deals, not one. The winning rule would be the rule that gained the highest total score across its ten battles.

Rules, or strategies, can be broken into three categories:

1. Rules that follow a pre-determined pattern.
   CCCCCC.... or DDDDDD.... or CDCDCD....
2. Rules that are random in nature.
   A die is cast and C is played for the numbers 1 to 5 with a D played for a 6.
3. Rules that depend on the behaviour of the fellow dealer.

Co-operate first up but then see what the fellow dealer does. If they co-operate then co-operate again but if they ever default then default back for the rest of the game.

In preparation for the creating of rules or formulae, we briefly looked at two very basic rules: always co-operate and always default. It was noted that the first rule could never produce a higher score than its opponent and that the second rule could never produce a lower score than its opponent. This does not necessarily make always default the winning rule.

Students were reminded that the winning rule would be the rule with the highest score after competing with every other rule in the round robin tournament.

Students were then given some time to meet in their small teams to start developing their winning strategy. The following lesson, each group leader presented their *Rule of Life*. The class considered each rule and helped to redraft rules where ambiguity in the application of the rule existed. This exercise is of great value as a demonstration of the power of the language and logic of mathematics.

Each rule, formulae or strategy if you prefer, was then pitted against every other rule and a score for each was calculated. This was achieved by having each team member complete 20 transactions against three rules from other teams. The results were tallied in a two-way table so that scores could be verified against the reverse result. Did the results of the deals between rules two and five agree with those for rules five and two?

Round	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
Me	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D	10
Them	C	C	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	2
Score	3	5	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	17
Against	3	0	5	1	5	1	5	1	5	1	5	1	5	1	5	1	5	1	5	1	57

Table 1. A typical individual score sheet.

All rules will have their good battles and their bad battles so it is virtually impossible for students to figure out which rule is winning, this builds great interest in the final outcome. Depending on the class, you might like to have the students tally the results themselves as a spreadsheet activity.

The mathematical skills required for this lesson are surprisingly basic, but the conclusions and the opportunity for further investigation are complex. Looking at the follow up studies based on Axelrod's initial competition it is clear that many a PhD has already been awarded for work on this idea and there remains room for many more.

Extension questions include: How might adjusting the scoring system affect the outcome? What if more deals had been conducted? Is it likely that if one or more of the weakest rules had been left out, or other rules had been included, that a different rule would have won? Are there any ideas for rules that you would try if you had another chance?

The interest generated by Axelrod's competition and results in 1980, lead to the running of a second and much larger competition. The same strategy won the second competition. The results weren't definitive of course because Axelrod couldn't be sure that a better strategy existed which had not been tested. What was the winning strategy? Tit for tat.

A rule that co-operates for the first deal and then matches the behaviour exhibited by the opposition on their previous move. What ever you do to me, I will do back to you - perhaps even an eye for an eye.

Now when I shared this research with my very wise wife, the mother of our five children, she immediately declared her doubt about this being the ultimate rule. Yes it might be prevalent at a young age, but tit for tat is not considered ideal behaviour in our home.

She had a gut feeling that mathematics would support behaviour of a more refined philosophy. So it has been with great interest that I have found that the competitions I have run have not supported Axelrod's findings. In fact over the years I have recorded several rules that appear to outperform tit for tat!

Axelrod's report claims that the advantage of tit for tat shows up in longer trials where it's ability to allow the opponent to change behaviour gave it an edge over rules like grim trigger, a rule that begins by co-operating but, if it is ever double-crossed, responds by defaulting ever after.

Simulation helps to show that grim trigger is actually a very dangerous strategy for the user, as well as for the other player. Professor Freidman submitted grim trigger as his entry to both of Axelrod's tournaments. In the first round, it scored 7th out of 14 submitted entries. In the second round, it scored 52nd out of 62 submitted entries. Clearly, it was not a very successful strategy.

What success it did have was due to the fact that it was never the first to defect. Being, in this sense, a nice strategy, it did as well as possible with the other nice strategies in the tournaments. In fact, being nice was the single best predictor of how well a strategy did in the tournaments. But other than being nice, grim trigger did not have much going for it. Of the 39 nice strategies in the second round, grim trigger finished 39th!

I accept the point Axlerod makes about the advantages of tit for tat but would respond by saying that second chance (co-operate until your opponent defaults a second time) combined with a regular reset (say after every 20 deals, or 50 deals) appears to make a far better choice. All of which makes for very interesting consideration for teachers, who are dealing with students on a very regular basis.

Running *Rule of Life* within your own classroom is surprisingly simple and challenges students to think mathematically in a very pure sense. In defining the rules by which they will compete they exercise the desire of all mathematicians, simplicity and clarity, and they gain an appreciation of mathematics as the purest form of logic.

If you would like a copy of my lesson plan, including spreadsheets for testing rules and for gathering results and handouts, or if you just care to comment, contact me via email. joe@mathsmate.net.

REFERENCES

Axelrod, R. 1984. *The evolution of cooperation*. New York: Basic Books.

https://cs.stanford.edu/people/eroberts/courses/soco/projects/1998-99/game-theory/axelrod.html

https://en.wikipedia.org/wiki/The_Evolution_of_Cooperation

http://sfgirl-thealiennextdoor.blogspot.com.au/2007/08/is-james-bond-altruist-part-2.html

What's the best lesson you've ever taught? Share it with other MAV members by submitting an article for a future edition of *Common Denominator*.

Email office@mav.vic.edu.au with the subject 'Common Denominator submission'. Please remember that your submission doesn't need to be word perfect - we can help with editing and shaping the article for publication.

YOU'VE GOT A VCAL CLASS

Jamie Gray - Peter Lalor Vocational College

Congratulations! You have been assigned a VCAL class in 2017, and you are excited about the challenges ahead. However, your previous experiences have not specifically prepared you for VCAL.

Therefore, as a new VCAL teacher the question you have is, 'Where do I start?' I strongly believe that the best place to start is to get to know your cohort of students and develop strong relationships with them. The majority quite like to tell you that they 'hate maths' or that they 'can't do maths'. Taking this on as an opportunity for discussion, we find that the students do have a number of strengths in a number of areas. Straight away, you are in a much better place to help the students, as they now perceive you as someone willing to help them out.

VCAL classes can be like a bag of licorice allsorts with multiple entry levels, varied vocational interests and diverse backgrounds. Therefore, our teaching should be strategically targeted to gain both engagement and success.

As with general practice, I do diagnostically test my students as soon as practicable at the start of the year. The students, when told why they are being tested, understand that the teacher needs to know the different student entry levels. As well, it provides the teacher with base data, as to the improvements and challenges that will arise during the student's learning journey.

We are fortunate as VCAL teachers that nearly all of our students will have a vocational focus. This provides the teacher with the opportunity to link their maths to their career pathway. It also provides a great answer to the student who asks, 'Why are we doing this?' A great resource in this regard is the VET (Vocational Education & Training) teacher, who, in my experiences has always been keen to share the various aspects of what the student is studying. As well, we learn how we as numeracy teachers can help the student better cope with the mathematical facets of the VET subject. Similarly, to their vocational interests, we can also offer tasks around student interest. A footy tips competition or looking over footy stats are always of interest to a student with an AFL passion or a fashion design student will likewise be inspired by dress design and measurement.

Just as a VCE teacher visits the VCAA website for VCE study designs, a VCAL teacher visits the VCAA website for the VCAL curriculum planning guides. These provide information regarding the four VCAL numeracy strand levels, learning outcomes, SATT (sample assessment task templates) information and activities, respective to the VCAL Numeracy levels. As well, the VCAA website provides a wealth of information about the QA (Quality Assurance) process, which all VCAL teachers are required to engage in.

QA PROCESS

The VCAL QA process seeks to ensure that there is a consistency amongst teachers around the design and assessment of the

tasks at senior, intermediate and foundation levels. It is compulsory that all providers participate in the QA process each year, by addressing a designated strand. In 2017, the regions that must submit Numeracy SATTs are Barwon South-West, Hume and Lodden Mallee. Other regions will have submitted other strands to their VCAL Liaison Teacher during March 2017. Each year SATTs providers submit at a particular level and in 2017, it is the lowest level administered to the students. The full process is available at the VCAA website, under VCAL Quality Assurance.

VCAL NUMERACY DELIVERY

VCAL Foundation Numeracy was written with the goal in mind that every student should be provided access and offered the opportunity of success to attain a senior secondary certificate. The three VCAL levels compare well with the concept of gradual release of responsibility, whereby at a Foundation VCAL level the teacher works closely with the student, frequently monitoring the progress of the student. Conversely, at a senior VCAL level, the student works in an autonomous manner accepting most of the responsibility for their own learning.

When outlining tasks, I do not spend a lot of time at the whiteboard. After introducing the task, I tend to provide a hands-on activity that everyone can engage in, regardless of his or her entry level. An example of this may be an origami task for the design outcome, whereby students are given an open-ended task and can explore different models, dependent upon their skill with the task. Often students will start with a simple design and then challenge themselves with designs that are more complicated. Following tasks should still respect where the student is at and so sequencing of learning and student reflection of learning is always forefront of mind.

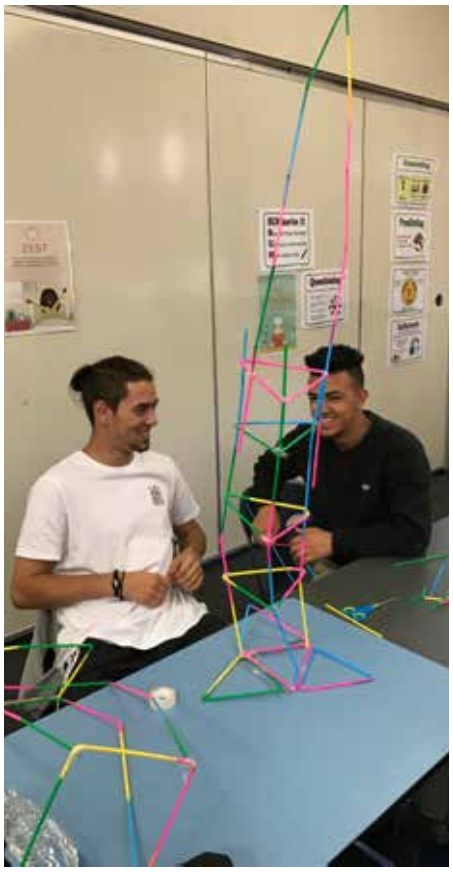
Recently, MAV in conjunction with the Victorian Responsible Gambling Foundation (VRGF) developed materials, specifically differentiated for VCAL students. Activities developed allow whole class discussion and participation in the task at the start and after, students select follow-up activities and worksheets at the VCAL level they feel comfortable to handle. These resources are available on both the MAV and VRGF websites.

VCAL COMPETENCY

'How do you know when a student is competent?' is a question frequently asked by VCAL teachers. Being more familiar with norm-based assessment or criteria-based assessment, I tend to rely on my VET teaching colleagues, who deal with competency-based learning a lot of the time, to guide me in this regard. Generally as a guide and not a rule, VET teachers like to collect evidence, using three different mediums over three different occasions. I choose to take this on board, when writing my SATTs, by including at least three pieces of evidence for each of the VCAL learning outcomes. In this way, students are provided the opportunity of displaying competence through their preferred learning style and teachers are given the flexibility of varying their delivery modes.

MAV AND VCAL

MAV continues to support VCAL numeracy teachers in a variety of ways. Most edition of this magazine, *Common Denominator*, include a VCAL article, looking at best practice at schools and providers around Victoria. MAV's annual conference has a number of workshops, specific to VCAL delivery and VCAL numeracy resources. As well, MAV is also taking a leading role in working with organisations to develop materials and resources, specific to VCAL numeracy.



Do you teach VCAL?

MAV is keen to receive article submissions from VCAL teachers for publication consideration. If you have an interesting story to share, email it to Darinka Rob, drob@mav.vic.edu.au.

EXPLORE YOUR ENVIRONMENT

David Cook

If you are yet to experience a mathematics trail then this article seeks to identify different starting points that may encourage you to incorporate this curriculum option. A mathematics trail can be described as a way to help students learn mathematics by engaging with their environment.

Traditionally a mathematics trail consists of a number of stops along a walk that requires responses to different tasks at each stop. Importantly, the location defines the learning context and each stop provides a unique opportunity to look at the environment through a mathematical lens.

MADE BY MATHS

The Mathematical Association of Victoria mathematics trail app, *Made by Maths* when originally launched, explored the mathematics of key landmarks, structures and architecture in Melbourne. The app was aimed at students and teachers to connect mathematical classroom learning with real world mathematics. In later updates the app's content was expanded to include walks for Swanston Street; Federation Square, La Trobe University and the National Sports Museum. You can download the *Made By Maths* app at the iTunes or Google Play store. In addition, teachers can register for free at www.madebymaths.mav.vic.edu.au which enables you to obtain a code to track and retrieve student work.

The latest addition to this app is aimed at providing the mathematics trail experience in your local environment. *Explore your Environment* provides ten stops that enable students in rural and metropolitan settings to explore the school environment through a mathematics lens.

GETTING STARTED

The mathematics trail experience takes students beyond their classroom to collect data and to apply their knowledge and understanding of mathematics to resolve a broad range of mathematical tasks. Digital technologies can be readily incorporated into a mathematics trail to assist in the capture, answering and sharing of the learning and a notepad and pencil can produce equally viable and valuable outcomes. The following scenarios reflect a number of observations and learnings gained from witnessing different classes,

teachers and schools implementing mathematics trails. The scenarios are intended to provide you with resources to facilitate a successful implementation of your mathematics trail experience.

A SCENARIO 1: CLASS A - IN THE DEEP END!

This class is unused to group work, independent activity and seldom ventured beyond their classroom. Armed with assorted stationery and unbridled enthusiasm the students were given a text based mathematics trail and headed into the school grounds. Although grouped, the entire class arrived at the first stop. The unnecessary stationery, overcrowding and novelty lead to confusion.

Learnings

- Ensure that the students have the prerequisite skills to capture the information at each stop. Note taking, drawing and labelling, photography or video production.
- Model the trail experience in your classroom or take your class to a location that can accommodate them.
- For trails that are linear in design (along a number of streets), stagger the starts, allocate different stops to different groups, enlist a number of helpers, strategically positioned along the trail.
- For non-linear trails, allocate different starting points to each group.
- Consider the time you have available. Use a scheduled mathematics period and focus on one stop and the sharing of solutions. Allocate a session that is free from other demands.
- Advertise your intention to conduct a mathematics trail. Letting your colleagues and the school leadership know of your intention can have many positive outcomes; offers of additional support, a sharing of expertise or affirmation.

B SCENARIO 2: CLASS B - SURPRISE!

Class B thrives on independent work and group work and are eager to experience something new. Detail is sometimes of less importance than getting started and moving on.

Learnings

- Being beyond the confines of the classroom can present challenges for your class and other classes. Follow your school's expectations and procedures to ensure the safety of your students, the work environment for other classes and the values of the school.
- Enlist additional help to assist you and your students, identify the areas of the school that can be accessed and the expected routes to be followed and position yourself strategically.
- Working beyond the classroom can highlight different group dynamics, unexpected skills and confidences and provide you as the teacher with new insights into your student's social and emotional skills.
- A mathematics trail stop requires the capture of data specific to that location. This skill can be assessed at each stop or during the sharing stage of the trail. The sharing of responses can be a critical component of the trail experience allowing the teacher to gather rich assessment information and to exploit authentic learning opportunities.
- Setting clear expectations and articulating success criteria can inform the experience.
- Effective feedback that focuses on the success criteria, identifies what has been achieved, what is required, what is next, and allows the feedback to be applied supports the learning process and the outcomes.
- One or two stops can produce sufficient opportunities to identify future learning directions and an appetite for more trails.

C SCENARIO 3: CLASS C - LET'S GO!

Class C have been well prepared by their school experience, they frequently demonstrate responsibility for their learning. This class has high expectations of the tasks they are expected to complete and represent a broad range of skills and abilities.

Learnings

- Rich learning experiences can often be the catalyst for new and unexpected learning. The mathematics trail challenges students to make decisions, to apply their knowledge and understanding and to communicate their findings to an audience.
- Mathematics trails can allow students to make multiple connections across the different curriculum areas.
- Manage the assessment data produced. Initially enjoy the experience that a mathematics trail offers and use a generic assessment tool, such as an annotated class list, to note observations, identify the potential available in the future and to inform your planning.
- A mathematics trail challenges participants to engage with their environment through a mathematical lens however opportunities for cross curriculum outcomes may also be presented, adding to the value of the experience.
- The mathematics trail experience can be a useful device in developing a growth mindset and changing perceptions about mathematics.

D SCENARIO 4: CLASS D - SO BUSY!

Class D is part of vibrant, busy school where teaching and learning competes for space in a crowded curriculum landscape. Data is important. Adding another component into the curriculum diet is a challenge. Beginning a new school year, a different year level and so many competing priorities to navigate, is this manageable?

Learnings

- Build confidence by using existing school processes and practices. Take a big-picture view and be patient. The learning journey is the key rather than completing another task.
- Set the scene by exploiting everyday situations, when walking to different locations within the school, when making class announcements, when packing up. Pose questions to focus your students on their environment and discuss the ways to capture the moment.
- Identify stops within the mathematics trail that relate to your learning focus. A balanced mathematical diet can be supported by exposing the students to rich activities, especially those that facilitate the students making judgements and choices. Completing one stop along a mathematics trail can provide a rich amount of learning opportunities across multiple curriculum areas.
- Setting high expectations of the learner, presenting challenge and modelling a preparedness to take risks and learn by experience represent sound learning principles.
- A mathematics trail experience has the potential to meet multiple learning outcomes while presenting an invaluable insight into your students, skills, behaviours and learning style. The design of mathematics trail promotes the opportunity for students to demonstrate their understanding.
- Mathematics trails are not an end in themselves but can be seen as a vehicle for future, deeper learning.

The mathematics trail process can be employed to promote:

- Parental involvement and active participation
- Student lead learning
- Differentiated learning
- Peer to peer and cross age learning
- Effective use of digital technologies
- Critical and creative thinking

To really connect students learning of mathematics and the world around them, mathematics trails are a great tool. There are a number of factors as discussed in this article, for teachers to contemplate before stepping out to make the most of the learning experience. Why don't you have a go and see where your mathematics trail may lead you!

REFERENCES

Boaler, J. (2016). Inspiring Students to Math Success and a Growth Mindset. *Depth Not Speed Archives - Youcubed at Stanford University*. Retrieved February 17, 2017, from www.youcubed.org/category/teaching-ideas/depth-not-speed/.

(2016, March 1). Home - Victorian Curriculum. *Mathematics - Curriculum - Victorian Curriculum*. Retrieved February 17, 2017, from http://victoriancurriculum.vcaa.vic.edu.au/mathematics/curriculum/f-10.

Lancaster, R. (2010). The Museum of Science, Art and Human Perception | Exploratorium. *Geometry Playground: Activities: Walk a Math Trail | Exploratorium*. Retrieved February 17, 2017, from www.exploratorium.edu/geometryplayground/mathtrails.php.

Here are some places to get started on your maths trail journey.

- **MAV's Made By Maths App** https://mav.vic.edu.au/resources/made-by-maths-app.html
- **Fitzroy Gardens** www.mav.vic.edu.au/files/student-activities/investigating-maths/IM_2.pdf
- **St. Kilda Road and Swanston Street Maths Trail** www.mav.vic.edu.au/files/student-activities/investigating-maths/IM_06.pdf
- **Walk a Maths Trail** www.exploratorium.edu/geometryplayground/mathtrails.php
- **COMAP Maths Trails** www.comap.com/product/samples/MathTrailsSample.pdf
- **NZMaths Make a Measurement Maths Trail** https://nzmaths.co.nz/resource/make-measurement-maths-trail

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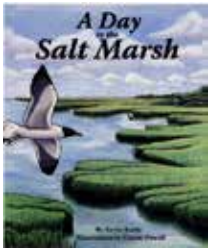
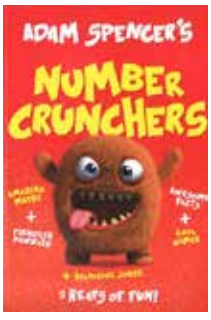


A DAY IN THE SALT MARSH

F-4

Enjoy a day in one of the most dynamic habitats on earth: the salt marsh. Fun-to-read, rhyming verse introduces readers to hourly changes in the marsh as the tide comes and goes. Watch the animals that have adapted to this ever-changing environment as they hunt for food or play in the sun, and learn how the marsh grass survives even when it is covered by salt water twice a day. An activity on adaptations is included in the *For Creative Minds* section.

$14.90 (MEMBER) $18.63 (NON MEMBER)



ADAM SPENCER'S NUMBER CRUNCHERS

F – VCAL

After the runaway best seller *Adam Spencer's Enormous Book of Numbers*, Australia's funniest maths dude is back with another bumper activity book for young and eager minds!

Packed full of games, puzzles, quizzes – along with heaps of stuff to draw, cut out, decipher and decode. Students won't believe numbers could be this much fun!

$15.67 (MEMBER) $19.59 (NON MEMBER)

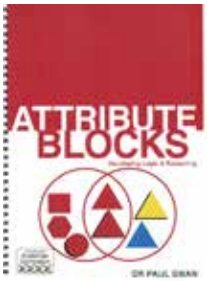
24 GAME

5–10

24 Game is an educational maths card game that sharpens your maths skills while having fun! Game cards are 4"x4" and double-sided. 1 Dot, 2 Dot and 3 Dot. Builds strong mental-mathematics and problem-solving skills; help improve test scores; sharpens concentration.

Pictured here is the Factors/Multiples 96 card deck. Other titles are also available; check out the MAVshop website for more.

$9.99 (MEMBER) $12.49 (NON MEMBER)



ATTRIBUTE BLOCKS, DEVELOPING LOGIC AND REASONING

F-6

The games and activities contained in this book are designed to focus on the problem solving and reasoning proficiency strands from the Australian Curriculum: Mathematics. In addition students understanding of fundamental mathematical principles will be enhanced.

$21.45 (MEMBER) $26.81 (NON MEMBER)

ONE IS A SNAIL TEN IS A CRAB

F-4

If one is a snail and two is a person - we must be counting by feet! This is a fantastic story to stimulate students' counting skills and could be used in any primary classroom. The discussion may include skip counting and other rich mathematical discussion promoting additive and multiplicative thinking. This book can be used for a whole class mathematical investigation.

$16.65 (MEMBER) $20.81 (NON MEMBER)

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