Middle years students

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The Insightful Classroom

Issue 11
Mar 2014

Regular Insights, Tips and Pointers for Australian Maths Teachers

Middle Years Students

Making the biggest difference to kids when it really counts

>>> Critical Number concepts: grades 3-7

Relative size, Multiplicative Thinking and Proportional Reasoning

In our last edition we examined two concepts in number that are critical to get right during the first three years of school. In this article we pick up where we left off by examining three concepts that make the biggest difference between grades three and seven. As students often come to high school still missing these concepts they can also go a long way to improving results in grades 7-9.

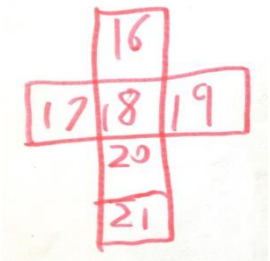
Relative Size and Place Value:

Place value is one of the Big Ideas in number identified by Dr Dianne Siemon during the National Middle Years project as pivotal for later mathematical development. Students who are missing place value concepts in middle primary school are in significant danger of failing high school mathematics.

I have found that there is a specific understanding within place value that causes the most difficulties for students. I call this Relative Size. Simply put, it is the understanding of how big numbers are when compared to each other. Many students can make representations of numbers with blocks, write numbers in words, in digits and in expanded notation, order them and perform simple operations yet do not understand that 800 is further away from 1000 than 100 is from one. Difficulties with relative size often tend to go undiagnosed in normal classroom routines, with teachers struggling to find out what is holding a particular student back. With this in mind, here are a few simple diagnostic tasks to try with your kids.

Grade 2/3: Parts of a hundreds board

Draw 6 squares into a cross shape. Explain to the kids that this is part of a hundreds chart. They need to work out the missing numbers. At the top of the cross write the number 16. Check to see that they understand that the numbers increase by 10 when going down and by one when moving from left to right. You can see here from Brittney's chart that she hasn't developed an understanding of this pattern yet and is rote counting by ones.



Grade 3/4/5: Open number line from 1 to 1000

Tape one straight line of masking tape most of the way across your classroom. Place 1 MAB cube at one end, and 1000 MAB cube at the other end. Ask each child to draw the number line on their A3 piece of paper with the 1 and one end and the 1000 at the other. Tell them to write where 10 and 100 should go on the line. Common misconceptions to watch out for include: equally spacing the 10 and the 100, placing 100 in the middle, placing 100 at about one quarter of the line's length (closer to the one), and placing the 100 up near the 1000 because it is a "really big number". I have used this diagnostic task with several thousand students and have found that this concept is missing in approximately 80% of year threes. The more concerning result is that this concept is still missing in approximately 50% of year sevens.

Grades 5/6/7: Relative size of decimal numbers compared with whole numbers

Ask the students to make 23.7 using MAB. Watch for students who think that it can be made by using 23 blocks, then leaving a space or putting a dot, and then making another 7. If they do this, push the blocks back together and ask what it is now (they may say 30 once the space or "dot" is no longer showing, but think that the 30 turns into 23.7 as soon as a space is visible). These students may also think that 23.7 becomes 24.6 if one of the "point seven" blocks moves across the point to the other side, or that 23.7 becomes 7.23 if you rotate it. Separating 30 blocks is not the same as 23.7! Decimal numbers are about relative size, not about a dot. Watch out as well for students who want to make the "point seven" by cutting one block into halves, quarters, eighths, or sevenths rather than into tenths.

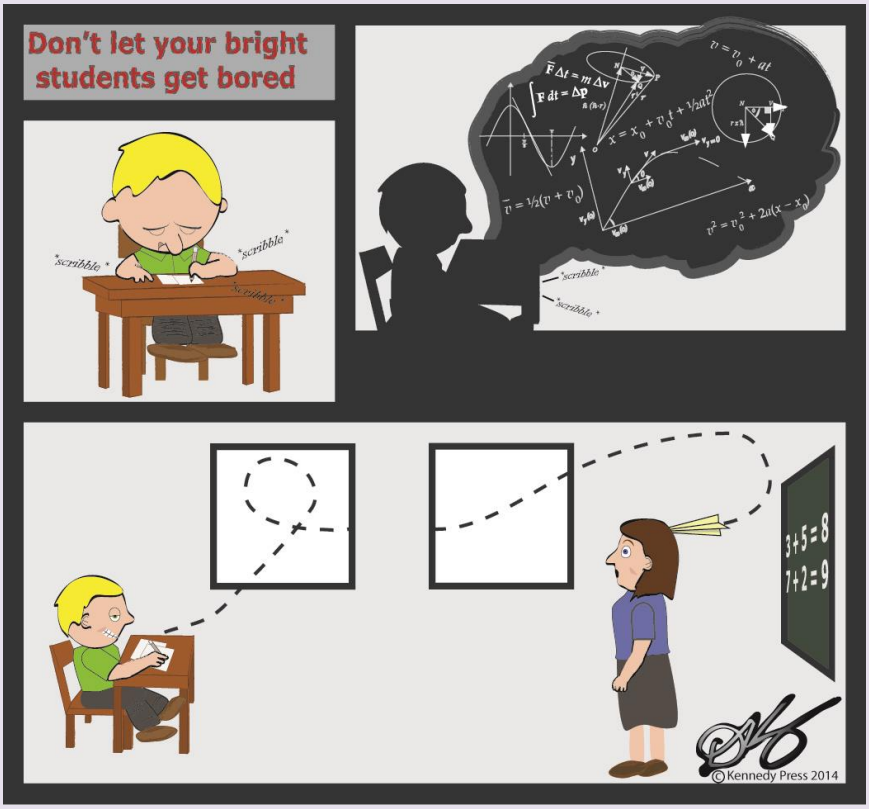
…Continued over page

Awesome maths questions to use with upper primary kids:

Back to Front site subscribers:
Click Here to download these and other resources

Students in the middle years of school are often very bored in maths classes. They fail to see the relevance of what they are learning, they often feel stupid and they have given up on trying. Here are a few of my favourite maths investigations to get them excited in class…

- Youth definitions and media stereotypes: How are youth portrayed in the media and is that a fair representation?
- Computer games and reality: examine how the base-two system is used in computer codes
- MP3s: How many MP3s are owned by the people in our class? How much data is that?
- What would an "average" youth actually mean? How could we define "average" statistically? Would any of us actually fit the "average"?
- Designing a fitness program for my parents: Examine the ways to measure fitness and then examine which fitness activities target specific aspects of fitness.
- Earning money and saving for something awesome.
- Shopping and sales



>>> Critical number concepts … *continued*

Multiplicative Thinking: picturing multiplication as an array rather than as "groups of"

Termed "multiplicative thinking" by Professor Dianne Siemon, arranging numbers into arrays is a pivotal point in the development of student thinking. Being able to think in a grid-like structure and to conceptualise numbers in two and three dimensions is essential for the understanding of area, volume and later conceptualisation of algebra (such as the factorising of quadratics). Multiplicative thinking is also one of the concepts that I have found significant numbers of teachers across the country are missing. Why don't you try out this task with your staff (or for yourself) to see what happens?

Firstly, try to multiply 23 by 35 without using a standard written algorithm. You can break the numbers up into bits, draw it or use mental strategies – just don't do the written algorithm mentally and pretend that you did something unique! What answer did you get? Now draw a quick sketch of what it looks like to multiply 3 by 5 – your first image.

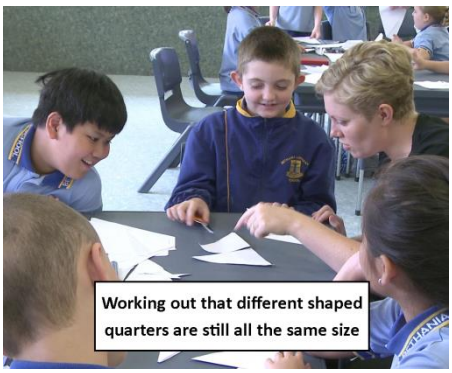
I have found that huge numbers of teachers end up with 615 for this question instead of 805. There are often a few other answers as well, but I consistently find that at least 25% of primary teachers get 615. This is achieved by multiplying 20 x 30 (600) and 3 x 5 (15) then adding these together. But now here's the killer… Well over 90% of teachers who get 615 draw a picture with "groups of" or additive model (e.g. 3 circles with 5 dots in each, tally marks). On the other hand, teachers who end up with 805 almost exclusively draw an array or grid (3 rows of 5, or 5 rows of 3).

If you have ended up with 615, try drawing 23 x 35 as an array and seeing what it looks like. Once you have your rectangle, divide the side with 23 into a 20 and a 3 part. Draw a line or fold your rectangle to show the two different parts. Then repeat with the 35 side, breaking the 35 into a 30 part and a 5 part. You will find that you have now broken your rectangle into four parts that are different sizes and shapes. The smallest part is 3 x 5. The largest part is 20 x 30. Those are the two that you used in working out 615 as an answer. Which parts are you missing?

Proportional Reasoning: How big is the part compared to the whole?

When I ask teachers which concept kids find the hardest the answer is almost exclusively, *fractions*. Yet just as with place value, most kids are ok with very standard looking fractions such as pizzas. The difficulty that they have is linked with relative size within place value – it is the relative size of parts within a fraction compared to the whole. This difficulty with proportional reasoning is not limited to fractions, but also tends to also be present in decimal numbers, percentages, and even part: part comparisons in ratios. Often kids think that fractions are about the number of parts that one whole is broken into rather than the size of the parts. For example, a circle that was divided into half, with one half divided into two quarters could not have all of the pieces being called "thirds" even though there would be three parts.

Grade 3/4/5/6: Uneven halves



Ask students to make as many different halves as they can using an A4 sheet of paper as the whole. Test each guess to make sure that each really is a half. Label each half with a different letter and stick to the board. Ask students which half they think is the biggest (they are allowed to vote for more than one, but do NOT lead them by saying "or are they all the same" – you are diagnosing if they realise this or if they think that shape changes size and if you say something like this they will all vote for that answer). Watch for kids who think that the orientation or the shape of a half will change how big it is (triangular halves are much bigger than rectangular halves). Also watch for students who think that halves must be symmetrical rather than the same size.

Grades 4/5/6/7: Uneven thirds

Unfortunately many students do not seem to generalise what they have learned about halves to other fractions. To check this, draw a circle on the board. Draw a line to cut the circle into halves. On one half, draw a line to cut that half into two quarters, but leave the other half as it is. Colour one of the quarters. Ask the students what you have made. If they say thirds, cut the other half into two quarters and ask again. If they say "now it's a quarter", then continue cutting any of the pieces that are not coloured (leave the one quarter as it is) and ask again. Watch for students who think that you have made thirds (or "uneven thirds"): as they think that the name of a fraction relates solely to the number of pieces rather than the size of the pieces. Also, watch for students who think that even numbers also relate to evenly sized fraction bits – i.e. you can't make "even" thirds because three is not an even number (therefore any three pieces are called thirds), so while halves and quarters have to be even it doesn't matter for the rest of them. These students tend to call the pieces by the following names: thirds, uneven thirds, unequal thirds, improper thirds or irregular thirds).

If you would like to see these diagnostic tasks in action as well as strategies to fix these problems remember to order our **Professional Development videos**. All of the student photos in this article show sections of these videos. The series, *Back to Front Maths* also targets these understandings, showing teachers how to lead students to develop their own deep understanding of the connections between concepts rather than relying on rote learning and a good memory.

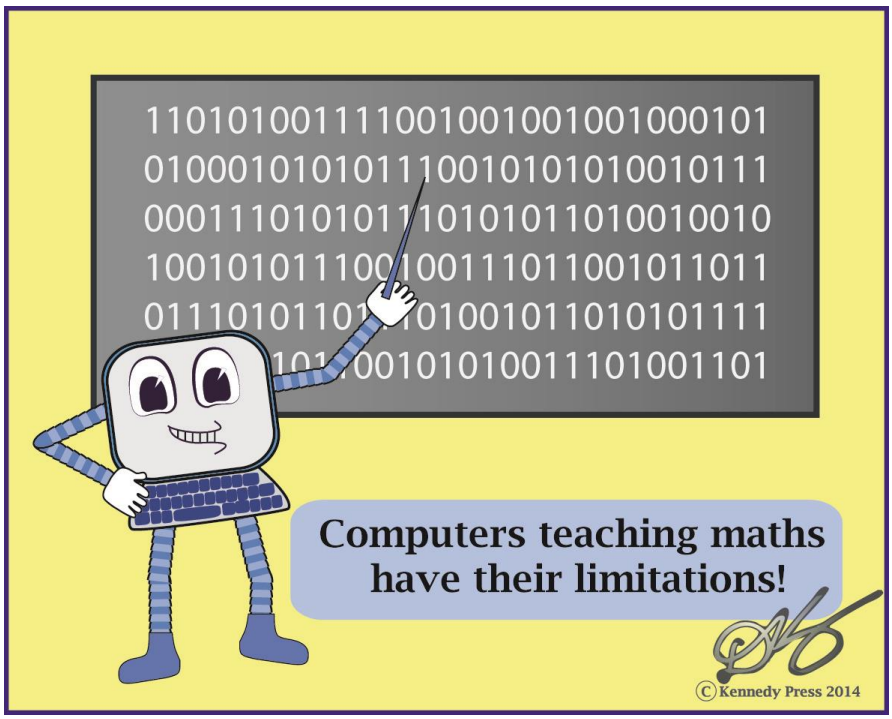
In our next newsletter we will be sharing some results of a pilot project in which several Education Queensland schools used *Back to Front Maths* to rapidly improve understanding of Place Value and Proportional Reasoning. The results are phenomenal, so keep an eye out and remember to share the results within your own district.

Depression, from a child's perspective – *Kathryn's story*

My cousin, Kathryn, was a gifted mathematics student and is now a successful scientist. Yet throughout high school, university and in her working life she has suffered from severe depression. I believe that Kathryn is not alone in her experience, so I have asked her to share part of her story with us… Tierney

By Kathryn

There are some things that I wish my teachers had understood when I was at school. Things I wish had been done differently, but that I couldn't really explain at the time. Sometimes it's hard to talk about even now, but hopefully by sharing my thoughts with you we can make school that much easier for another child.



Concentration can be a real problem with severe depression, making even the simplest tasks difficult to complete. I have found that simply following a conversation can be near impossible. Think of a time where you have been reading a book when tired and suddenly realise you have read the same sentence five times without absorbing what it said. Sometimes it feels like I'm trying to walk through quicksand with gumboots on!

Lack of sleep compounds the problem, although it isn't the root cause. Sometimes I had too much sleep, too little sleep, or it was of a really poor quality. It depended a lot on which medication I was on at the time. I personally struggled to stay awake in class through high school and university when I was required to sit for periods of time listening to a lecture or lesson.

>>> Depression, from a child's perspective – *continued*

Different medications can play both positive and negative roles at times –sleep, appetite and hormones can all be affected. They can really mess with your self-esteem if they cause weight gain or loss, worsen acne etc.

Keeping up with school work can be really hard in those conditions. I had a real problem with motivation. It was very difficult to even get out of bed at times. This had a huge impact on my time management, self-care (personal hygiene, good diet, etc), goal planning past the short term (particularly in senior, where Year 11 and 12 are meant to be an extended effort with a delayed reward).

In high school I procrastinated and most assignments were completed the night before due date, with **high levels of anxiety** and lots of tears. I worked around this at university by starting assignments as soon as I got them, to try and avoid the panic of approaching due dates. However, I often required extensions when hospitalisations broke up my schedule. I was also more **susceptible to stress** and often felt anxious.

The **apathy** that depression brings also makes it hard to want to do things socially or even be around other people. **Isolation** doesn't feel good, but sometimes you feel that you just can't face being around others or that you don't have the energy to go and force yourself to pretend to not feel depressed. You can be surrounded by friends and loved ones but still feel very alone – this may seem counterintuitive if you have never experienced depression. In social situations people often feel discomfort around someone who is upset, especially when normal methods of "cheering up" don't work. The cognitive dissonance of trying to hide your sadness or lack of emotion can be more distressing than just staying home alone.

There is a lot of pressure is put on school leavers to finish school, decide what they want to do in life, and get on with doing that. If I could give one message to students with depression, it would be this:

There is time.

Don't feel that you need to have your whole future planned out and put in action before you're 18. Don't feel that you will never go to TAFE/Uni/follow your desired career if you need to take a break and get back on track. There are other options out there, whether it be completing senior over an extra year, bridging courses, TAFE certificates etc. There is no single path to success, and the paths to success don't always run in a straight line.

There is time.

Take away tips for teachers:

- Give outlines to help with concentration during class
- Allow moving around during class to combat sleep and concentration problems
- Try to use several shorter problems rather than whole repetitive exercises
- Help with planning: time management, assignment outlines, study sessions focusing on the most important concepts first
- Work with parents to notify them of upcoming due dates including exams (including handing out assessment schedules if possible)
- Give extensions when reasonable
- Consider the stress levels of the kids – remember that not everything needs to happen right now. There is time to fix it.

For more great resources, check out these sites:

Kids matter:
https://www.kidsmatter.edu.au/families/mental-health-difficulties/depression/depression-how-depression-affects-children

Black Dog Institute: http://www.blackdoginstitute.org.au/public/depression/inchildren.cfm

Help Guide: http://www.helpguide.org/mental/depression_teen.htm

Awesome things to do to help your kids with maths at home!

When they are really little:

- When getting them dressed, count their fingers after you put their hand through a shirt to check if there are still five, then celebrate that there are still five
- Play repetitive, anticipation games: round and round the garden (pausing slowly for one step, two steps), sneaking up and saying "boo", clapping to music
- One for me and one for you… sharing games.

As toddlers:

- Ask them to get out the cups and plates for afternoon tea without telling them how many are needed (only maximum of 3-4 people)
- Ask them to get the right number of pegs when hanging out the washing (e.g. shirts need two, socks need one)
- Talk about how things are similar and different (e.g. this one is pointy but this one is rounded), and classify the same group of objects in different ways (colours, shapes, "pointy", "rough"…)
- With two or three objects, move them around and ask how many there are now. Keep experimenting until the child realises that moving the objects doesn't make the number change – there are still the same amount.
- Don't always count things in a line or from left to right. Try a circle or just a mixed up group. Also, count mixed groups of objects (e.g. a block, a lego man and a ball) rather than always the same things. Mix up the colours too.
- Focus on understanding what changes a number and what doesn't rather than on counting to ten or twenty. Counting without understanding quantity is useless.
- Give them different sized cups to play with in the bath instead of toys. Pour water from one to the other to compare which has the most.
- When building with Duplo, talk about the blocks as "a six block" or "an eight block". Experiment with ways to cover an eight block with other smaller blocks.
- Play skittles (six plastic bottles works well). Talk about how many you knocked down and how many are left to get.
- Share groups of objects between multiple kids (fairly).
- Use digital clocks (e.g. you can get up from your rest when the clock starts with a three, you need to get ready for your bath when the clock starts with a six).

In lower primary:

- Repeat all the toddler things, but with numbers to ten or twenty.
- Ask the kids to get numbers of items in the shop (e.g. 8 apples)
- Make "cool high fives" by using some fingers on each hand (e.g. 3 on one hand and 2 on the other). Repeat with other numbers bigger than five.
- Cut bread in half in different ways and decide that no matter what shape it is, both halves are the same.
- Give all the toast for the whole family cut into halves on the one plate (or apples, or other fruit). Ask how many pieces of bread or fruit you started with.
- Play "what am I spying?" instead of "I spy": Describe a 3D object that you can see, one clue at a time, while the other people try to guess what it is. (e.g. My object is bigger than the TV. It has smooth sides that are rectangles. It is white. It has two doors on it. It is very cold.)
- Look at maps of where you are going and let the kids try to follow the map while you get there. Find your street on a map.
- When another family is coming to dinner ask the kids how many people there will be. So how many pieces of broccoli will we need if everyone has two?
- Work out how many pieces of pizza you need for your family and how many pizzas that would be.
- Talk about how likely things are to happen (e.g. it is very likely to rain tomorrow so we had better pack your rain coat). Consider things that are totally made up in their games or that they see on TV too – how likely is it that the dinosaur bones that David Attenborough was just looking at actually came to life and walked around the museum?
- Get them to budget their pocket money (e.g. have a money box with four categories: spending, saving, charity and gifts). Work out how many weeks it would be before they could buy a certain toy.
- Get the kids to work out how many minutes it is until something happens (e.g. how long until your swimming lesson?). Both digital and analogue clocks are great for this.

Back-to-Front MATHS

In middle and upper primary:

- When playing board games (e.g. snakes and ladders or monopoly), use two dice. Let the kids choose if they want to move forwards by both, back by both, or forwards by one and backwards by the other.
- Let the child work out the logistics for their birthday party (or dinner, or a camping trip etc.) – how many cups, plates, packets of lollies etc. for the guests… as well as the timing (e.g. everyone will be here by 4:00 so we will play games until 4:30 and then serve cake. That will take 15 minutes. Then…)
- Arrange groups of objects into different arrays (like 12 muffins in a tin vs 12 eggs in a carton). Use existing arrays for calculations (e.g. looking at a wall of shoes in a sports shop, work out how many shoes that represents, calculate how many rooms in a hotel by counting the floors and the number of windows in each floor)
- Talk about how likely something is to happen and give your surety a numerical measure (e.g. a 50% chance of rain vs a 90% chance of rain according to the weather predictions)
- Let the kids cook – particularly recipes involving fractions of cups etc. High school kids can cook meals once each week. Plan them together and consider how healthy they are.
- Plan routes on maps. Work out the total distances involved, but also talk about the traffic and whether one route would be faster.
- When on the highway, estimate how long it would take to get to the next town given the speed limit and distance.
- Budget and save for holidays or larger items. Work out a payment plan (e.g. washing up is worth $__ but mowing the lawn is worth $__). Get them to figure out how to earn the amount of money that they want. Consider incentives (e.g. every time you save $20 we will contribute another $5) or loans (yes you can borrow the $50 from us, but you have to pay us back $55).
- Work out the sales price and original price on items when shopping to decide if something is worth buying.
- Talk about how much you pay in rent or home loan repayments. Talk about the cost of utility bills and let the kids look at the bills.
- Read medicine bottles and work out dosages together.
- Work out a timetable for the week together so that all the jobs get done without anyone getting cranky. Make sure that you allow time for homework, music, sports, getting chores done, family nights etc. That way you can plan for upcoming events (e.g. school projects).

A word to HOCs

Why Richard was sneaking into my maths class: Risk-taking and the link to Engagement

Tierney Kennedy - Education Consultant, Author and Editor

Year 8 support maths: could there be a class that would strike more fear into the hearts of teachers… or kids?

By year 8 kids have decided if they are "good at maths" or not. They know it. They believe it. And sometimes we are guilty of believing it too. So we dumb the maths down… telling them how to do every equation, memorising steps in their simplest form and killing any possibility for engagement in the process.

So in my mind it was high time to do something a bit different. I had free rein too. The exact words were, "Do whatever you want… they're never going to pass anyway."

Having *not* punched the speaker in his head, I decided to take him at his word and experiment. It was time to make some serious changes. It was time to push the kids to take risks and solve hard problems instead of getting by with doing the minimum.

Every new concept was approached as a problem. Kids had to think hard, work together, try stuff and work it out.

Richard was in my experimental grade 8 class. He was "classified" as both ASD and ADHD.

After term 1 Richard received a B, so I bumped him from support to core maths for term 2. That was when the problems started…

I found Richard hiding under desks, under chairs and behind doors.

During that term Richard was thrown out of core maths within the first five minutes of every lesson. For the next 40 minutes he tried to sneak into my class!

Why?

The content wasn't any different.
The classroom wasn't prettier.
There weren't any computers,
Ipads, games or videos.

The difference actually was far simpler than that… I made him think. I made him work things out. I refused to let him slack off or tell me that he couldn't do it. I celebrated his successes and pushed him to solve problems.

In The Next Issue >>>

Transitioning well from Upper Primary to Lower Secondary

Concepts to get right, effective teaching approaches and getting past the "maths shield" to create a risk-taking classroom

Engaging kids in the middle years doesn't require fancy technology or beautiful locations. There is a big difference between engagement and entertainment. Engagement requires a far more "minds on" approach.

The ultimate way to engage upper primary and lower high school kids is to require them to take a risk and try to solve something really hard. Thinking is internally motivating. Since I first read his work in 1999, James Bean has inspired me: "We believe that young people have the **right** to be intelligent." (Beane, 1996) Intelligence is a right often denied to support students. Let's give it back.

Tierney

Would you like to know more? To subscribe to this FREE newsletter and receive practical tips, techniques and discussion of developments in the field, email manager@kennedypress.com.au with "SUBSCRIBE NEWSLETTER" in the subject. Alternatively, visit www.backtofrontmaths.com.au/teachers

Feedback and questions are always welcome: Contact Education Consultant Tierney Kennedy at tierney@kennedypress.com.au

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Facebook Group!

Maths Matters is a Facebook group designed especially for teachers. We have discussion boards which offer tips as well as space to ask real questions from real teachers. Search for *Maths Matters* and choose "like" join us.

Teaching Back to Front with Tierney

Professional Development DVD Set

Light-bulb moments don't just happen – teachers *create* them!

In this eight-part series, Tierney Kennedy shows teachers how to use problem-based teaching to diagnose and confront student misconceptions, lead the students to develop deep understanding and generalise mathematical principles to different areas.

Eight lessons show problem-based teaching in action:

- Foundation: What changes a number and what doesn't (Number Conservation and Partitioning)
- Grade One: Relative size of numbers to ten
- Grade Two: Relationship between tens and ones
- Grade Three: Relative size of numbers to 1000
- Grade Four: Is one half really one half? (Proportional Reasoning with halves and quarters)
- Grade Five: Relative size of decimal numbers
- Grade Six: Double digit multiplicative thinking
- Grade Seven: Adding fractions with unrelated denominators (Proportional reasoning with thirds, fifths and improper fractions)

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