Mathematics for the 21st Century: turn it on.

Australian Association of Mathematics Teachers
Susan Hyde, Principal, Australian Science and Mathematics School.

www.asms.sa.edu.au
In this, the 21st Century, if we don’t understand how mathematical concepts drive the way of living, working and knowing, then we will be locked out of the opportunities for living and earning.

Strangely, our students seem to know this – even as far back as 2012, Australian students report in the PISA that maths was important. (PISA in Focus)

Indeed, according to Andreas Schleicher, OECD countries spend up $236B per year on Mathematics education. (Centre for Curriculum Design, 2014)
Trouble is, in Australia, learning mathematics has an image problem.

Many of our students report ‘maths anxiety’, and a body of research is building about how our students get anxious about learning mathematics (PISA in Focus #48 2015).

The PISA research reports that students feel more anxiety when learning maths in high performing schools, and, the level of anxiety is related to how well each student performs in relation to others.
Worse still, there is a gender issue; more girls report feeling anxious about learning mathematics, (Buckley, S, and Reid K, ACER 2013; PISA in Focus #2015).

Even so called ‘bright’ girls who can demonstrate that they can operate complicated mathematical concepts feel anxious and less capable when learning and doing mathematics. (Dweck ).

Sue Wilson (2015) says that new research has confirmed that some primary school teachers mark boys’ maths tests more favourably than boys.

Some of you might remember the research of the 1980s when we discovered that teachers of both genders give more attention to the boys in the class. Most teachers feel uncomfortable about this and deny it.

I encourage you all to track the attention that you give to the genders in your classroom, that’s if you have the courage.
As you all know, not to continue with mathematics into the senior secondary school will lock you out of many jobs which we can identify now, and many that have not yet emerged.

How did we get to this situation?
The PISA has shown that not all countries have this problem (PISA in Focus #48 2015). We all marvel at the mathematical dexterity of many of our Asian students where too many Australian students struggle.

As a school leader this is very worrying indeed. To me this situation means that what we are doing is not working.

Mathematics teachers and their associations are also worried, as are our policy leaders – note the focus on improving STEM education across the nation.

Trouble is, it is now not a matter of doing what we do better, we need to do something different about it, and it needs to be soon.
Let’s go back to the image problem.

I do not know how many times I have heard at a parent interview night “It’s okay Johnny, I wasn’t good at maths when I was at school”.

And what about the look of awe and sometimes fear when you mention you are a maths teacher? This is not a good situation.

So can all students learn maths?
I mean

You have a certain amount of intelligence and you can’t really do much about it.

Yes? No? Maybe?

If you have to struggle to learn something it means you are not good at it and should give up before spending a lot of unnecessary time on it?

Yes? No? Maybe?
The first thing we maths teachers need to get our heads around is the idea of mindset.

Carol Dweck’s research (2000) is well known thus I am assuming that you know about the fixed and growth mindset theory that has emerged from cognitive science.

Geoff Masters (2011 page 1) explains it well; “Some students appear to view ability as “fixed” and something over which they have little control.” The way that high achieving and low achieving students respond to this belief as learn mathematics has difference outcomes, both limiting their learning outcomes.

Trouble is, we maths teachers, and in fact just about the whole country have fallen for the fixed mindset, that is, we are born with a fixed amount of ability to learn mathematics, or anything for that matter. I am wondering how you respond to these questions? Please note your response.
Cognitive science and neuroscience have shown that we are not born with an intelligence rating.

Our brains are not hardwired nor do we have a fixed number of neurones that start dying from some arbitrary age.

The neuroscientists tell us that neurones continue to grow and replenish, and learning is about growing the connections between neurones.

The brain is not an empty vessel in which to pour knowledge.

For learning to happen the brain has to have some idea of what the concept is.

To learn new knowledge, people need to able to connect ideas and facts to the concepts that their brain has already developed.

Talking with others about what you are learning, and manipulating objects, drawing; activities to help the learners to connect new ideas to the concepts that exist in their brains and challenge misconceptions that might have developed.
Trouble is – do we, the teachers, the school leaders, the students, actually believe this?
Do we allow our students to learn the way that their brains are wired to do so?

Or do we suffer from the Semmelweis Reflex (chronotopeblog.com/2015);
the tendency of educators to dismiss the scientific evidence if it does not agree with their world view,

and in this case how students learn mathematics, how much they can learn and the methodologies that are needed to promote learning?

Now that we are 15 years into the 21st century, and we how their consider what I would regard as our rather dismal progress in ensuring every student can learn mathematics, it is vital that we have the courage to stand back, consider what is not working and find new ways to ensure our goal.

It seems that the 20th Century school design features such as one maths teacher, for one class, of one “ability level”, in one year level, in one classroom, with one textbook, won’t do the trick.
Take “ability” grouping for instance; perhaps the most pernicious 20thC way of ensuring that many students are denied the opportunity to develop important mathematical knowledge and skills.

Mostly grouped by the results of one test, the students are sifted and sorted in a way that denies them a pathway into the very understandings needed for 21stC.

The Semmelweis Reflex is in full swing when the school leader tries to remove streaming requiring maths teachers to teach so-called “mixed ability” groups.

Driven by the belief that only some people have the ability to learn certain concepts in mathematics, students must be sorted into classes and then learn the type of mathematics that is “at their ability level”.


“But these easier streams with their focus on “low-level, applied learning .... deny students access to the essence and beauty of this subject.” Masters also points out the “Since the mid-1990s, the percentage of Year 12 students taking elementary mathematics has grown by 30% while the percentages taking intermediate and advanced mathematics have declined by 22 and 27 percent respectively.”

mmmmm Maybe streaming isn’t working?
That’s where Systems Thinking comes in, and I recommend this process for exploring the big issues that arise in school change processes.

Rather than react immediately,

- clarify the vision of what is the preferred reality,
- explore the mental models that might be supporting the event fuelled by assumptions and attitudes,
- ask why is it happening,
- explore the patterns and trends that might explain how the event has happened.
Bev Rogers (2014) explores how the fixed mindset about ability feeds 20thC school design features and the potential of the growth mindset of the 21st school design features.

In this brilliant analysis, Bev explains that if we have a fixed mindset about ability, we will stream students, thus the “top” students will be taught everything that has to be covered and the “bottom” students will get restricted version of what there is to know.

We will also see dissatisfaction with the way that maths is taught, resulting in a decline of students studying advanced mathematics and a long tail of underachievement.

This affirms the belief by teacher, students and parents that some student can’t learning maths, which feeds the fixed ability mind set and as a result, only some students are entitled to learn the full extent of the subject.
Instead, if a growth mindset prevails and it is taken for granted that learning mathematics is for all students,

students are not grouped by ability,

taught the big ideas by allowing them to explore maths through problem solving where they can work together and help each to learn challenging concepts.

This creates enjoyment, increases motivation, engagement to learn maths. Heck, they might even be enjoying it.

As result more students will be interested in studying advanced mathematics creating the belief that all students can learn this beautiful subject.
The feedback loops were clarified by using the iceberg analysis.
Here you can see how the iceberg tool helps to clarify the mental models, structures patterns that explain the underlying issues that have led to the event.
So, what can 21st C mathematics teaching and learning look like?

20c School design features
The way that teachers and students are grouped together. One teacher, one class in one classroom with the door closed.

The way that learning opportunities are designed, mainly one textbook and teacher lectures.

The spaces available for teaching and learning.

Resources available for teaching and learning.
Since the 20C this has happened to us.

If you are interested you can see the 21st C school design features in action at the Australian Science and Mathematics School, and in particular in the mathematics central study. Contrary to common belief, the ASMS is not a selective school, that is, the students do not to sit a test as part of the enrolment process.

30% of students who enrol in year 10 each year come from low ICSEA government schools and another 30% from private schools.

The ASMS has its share of students with disabilities and mental health and family issues. They all profess to be really interested in science and mathematics.

The gender balance is skewed 40% females, 60% males at this stage.
Age grouping of students may make it easier for teachers and administrators for creating the timetable.

When we create the classes we divide 260 year 10 and 11 students into two groups. To each group we assign 6 or 7 teachers. These teachers meet as a team for 100 minutes each week, to design learning activities, review the progress of students, design assessment tasks, mark and moderate assessment tasks, develop pedagogical content knowledge associated with the tasks, discuss and resolve problems and issues that arise from the implementation of the curriculum. The whole group timetabling of the year 10 and 11 students at one time, creates efficiencies in the timetable, thus generating the time for the weekly team meetings.
The curriculum, its design and resources is online in the virtual classrooms.
As I mentioned before, the ASMS is not a selective school. In 2015 cohort we tested the students with the PAT Maths test. We have in our class students who achieved from the 11th to the 99th quartile. Now that, according to the PATM is a mixed ability class.

The students and teachers knew this. Each student at the extreme ends were identified and supported, we were able to report a 95% pass rate (not good enough) in the 2015 semester 1.

Our quest is to develop self directed learners. They learn how to learn, discover what their strengths are, what they need to improve, and seek feedback. This requires a complete rethink of how we teach. This rethinking comes out of the teaching and learning teams. We are moving from the teaching as telling. We help students focus on their capabilities and collect the evidence to support their assessment.
Thus the teachers learning is a very important part of our innovation.

From the day it opened the ASMS made sure staff had a sustained time form professional learning each week. We adjusted daily times and close the school at 1pm on Tuesdays.

Staff are arranged in teams to share planning and reporting of their goal setting, inquiry question, evidence gathering and resulting learning.

Staff are offered a rich variety of other professional learning beyond the school such coaching, mentoring, short courses and post graduate study.

Some teachers are involved in designing and delivering professional development activities to teachers in other schools.
What mathematics do we need for the 21C?


What should students learn?
Paper #1 Branches, Subjects and Topics
Paper #2 Methods and tools.
Paper #3 Concepts and processes.

I have provided some links to international research that you might be interested in.
Learning mathematics in 21C
