Recent brain research tells us that everyone with the right experiences, messages and effective teaching can be successful in mathematics at the highest level (Boaler, 2016).

People’s incorrect beliefs about and negative attitudes towards mathematics have had a devastating impact on the teaching and learning of mathematics in our culture. Intense negative emotions around mathematics are not uncommon and are recognised as ‘maths trauma’ or ‘maths anxiety’.

Mathematics, more than any other subject, has the power to crush students’ spirits, and many adults do not move on from mathematics experiences in school if they are negative (Boaler, 2016, p.x).

Importantly, leaders should ask themselves and their teachers, parents and students about their beliefs concerning:

- What is mathematics and how is it best taught and learnt?
- Is one’s mathematics ability fixed and immutable or can it be developed?
- How do beliefs and attitudes influence maths performance?
- What is being ‘good at mathematics’?

What is mathematics and how is it best taught and learnt?

While learners may experience mathematics as a performance subject, made up of procedures, rules and calculations, mathematicians describe it as the ‘science of patterns and a creative, interpretive, beautiful and powerful subject’ (Devlin, 1997). Dr Chris Matthews, from the Quandamooka people of Minjerribah (Stradbroke Island), a senior lecturer at Griffith University with a PhD in applied mathematics, sees mathematics as a ‘cultural expression that provides another way to view the world’.

Look at Nos. 4 and 5 of Setting up positive norms in maths class (Boaler, 2015) (https://www.youcubed.org/positive-classroom-norms/). How might you use this at your site?

Taking a cultural perspective of mathematics will engage students’ imagination and creativity and provide students with a strong understanding of what mathematics is and why we do it. Connecting culture and mathematics will allow Indigenous students to learn mathematics from their own cultural knowledge and first language (Matthews, 2015).

Changing learners’ experience of mathematics is not as simple as changing the nature of the mathematical tasks that teachers set: ‘For change to be successful, teachers’ beliefs, attitudes and practices need to be aligned.’ (Ontario Principals’ Council, 2009, p.13)

What do the practices and actions in your classrooms and site indicate about your beliefs?

In The principal as mathematics leader (Ontario Principals’ Council, 2009), Stipek and colleagues found that teachers who didn’t enjoy or feel confident about teaching mathematics were also those who articulated very traditional beliefs about maths. However, teachers who were more positive and confident about teaching maths expressed beliefs that were more reform-based (Stipek, Givven, Salmon & MacGyvers, 2001). They suggested that increasing teachers’ self-confidence in mathematics by building their mathematical understanding could be important in moving teachers towards more inquiry-oriented beliefs and practices (Ontario Principals’ Council, 2009). This is best achieved by involving teachers in ongoing job-embedded staff development that revolves around mathematics teaching and learning to improve their understanding and confidence (idem).
What job-embedded learning do you facilitate to improve mathematics teaching and learning for both teachers and students? Do your teachers have access to a reference book about the pedagogical content knowledge and the development of mathematical concepts? (e.g., Van De Walle, Karp & Bay-Williams, 2016 or Siemon, Beswick, Clark, Faragher & Warren, 2015)

<table>
<thead>
<tr>
<th>Traditional beliefs</th>
<th>Reform-based beliefs</th>
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<tbody>
<tr>
<td>Mathematics is a set of operations to be learned.</td>
<td>Mathematics is a tool for thought.</td>
</tr>
<tr>
<td>Student’s goal is to get correct solutions.</td>
<td>Student’s goal is to understand.</td>
</tr>
<tr>
<td>The teacher needs to exercise complete control over mathematics activities.</td>
<td>Students should have some autonomy.</td>
</tr>
<tr>
<td>Mathematics ability is fixed and stable.</td>
<td>Mathematics ability is amenable to change.</td>
</tr>
<tr>
<td>Extrinsic rewards and grades are effective strategies for motivating students to engage in mathematics.</td>
<td>Students will want to engage in mathematics tasks if the tasks are interesting and challenging (not for extrinsic rewards).</td>
</tr>
</tbody>
</table>


Is one’s maths ability fixed and immutable or can it be developed?

Recent brain research tells us that everyone with the right experiences, messages and effective teaching can be successful in mathematics at the highest level (Boaler, 2016). Professor Jo Boaler acknowledges that some teachers find this difficult to accept ‘especially if they have spent many years deciding who can and who can’t do math and teaching them accordingly’ (p.4). This is not saying that everyone’s brain is the same; it is saying that brain differences at birth are far less significant than the influence of learning experiences in rich and challenging environments (Wexler in Thompson, 2014). Therefore, the message struggling learners should tell themselves is not ‘I can’t do this’, but ‘I can’t do this yet’.

This is a really important message because people need to believe in their ability to learn maths – mathematicians are not born. Too often in the UK we talk about ‘mathematical ability’ whereas in other countries such as Japan or Singapore, emphasis is put much more on effort than ability (Churchman, 2015).

Look at No. 1 of Setting up positive norms in maths class (Boaler, 2015). Watch the first video link on brain plasticity and discuss what beliefs held by your teachers, parents and students this new knowledge challenges.

**Fixed and growth mindsets**

The work of Carol Dweck on fixed and growth mindsets is particularly relevant to the learning of mathematics (Dweck, 2006a). Researchers have shown that learners who develop a growth mindset, believing that they can develop their intellectual ability through perseverance and effort, have positive attitudes and ongoing growth in mathematical achievement (Boaler, 2016, p.6). On the other hand, those with fixed mindsets perform poorly across the achievement spectrum, as they believe that talent is something you either have or you don’t and, no matter how much effort is expended, it does not change. High achieving girls can be particularly vulnerable if they believe in a fixed mindset, losing confidence when faced with intellectual challenge, becoming fearful of no longer being seen as smart if they make mistakes. On the other hand, when they recognise that working hard develops skills and ability, it is less likely that their confidence or their performance are undermined (Dweck C, 2006b).
How do beliefs and attitudes influence maths performance?

The messages we give students can change their performance significantly.

Parents’ beliefs and attitudes

In a new study, neuroscientists Erin Maloney and colleagues found that parents with maths anxiety who frequently helped their children with maths homework in the early years diminished their children’s learning of maths (Maloney, Ramirez, Gunderson, Levine & Beilock, 2015). Research shows that when parents experience maths anxiety, they often hold poor attitudes about mathematics, considering it of little use and expressing low motivation to succeed in math. This in turn demotivates their children, increasing maths anxiety and reluctance to embrace challenge. However, if parents’ maths fears can be reduced, this will lead to more positive homework experiences, and most likely result in improved maths achievement and diminished maths anxiety for their children.

What beliefs about mathematics do your parents and community have? Check out the youcubed parent website (https://www.youcubed.org/parents/), especially the parent resource on six ways to support their child’s mathematical development.

Students’ beliefs and attitudes

Brousseau identified a common expectation in many mathematics classrooms which he termed the ‘Didactic Contract’ (Brousseau, 1997). When students ask for help, they expect their teacher to break down the problem and make it easier, thus diminishing the cognitive demands of the task. Thus, rather than thinking, reasoning and sense-making, students consider their role is one of ‘paying careful attention’ (Boaler, p.46). However, when learners seek relational understanding (knowing what to do and why), ideas make sense and there is an affective as well as a cognitive benefit. This fosters a positive self-concept and gives learners the confidence that they can learn and understand mathematics, diminishing maths anxiety (Van de Walle et al, 2014, p.29). Many Aboriginal students will need encouragement to take risks when learning mathematics, as they are traditionally taught to observe and wait until they are confident they have mastered a skill (Perso, 2005).

Teachers’ beliefs and attitudes

Teachers bring their own learning experiences as students to their classrooms and yet often teach the way they were taught. ‘Many teach mathematics with their own fear’ (Boaler, 2016, p.8). If they experience difficulties with mathematics, they may not offer challenging mathematics to learners in their classes. Learners are not likely to foster positive attitudes to learning mathematics if their teachers ‘fear’ or dislike the subject.
What is being ‘good at maths’?
What do your teachers reward in their classrooms? In traditional classrooms, teachers and students often value and reward the correct answer which fosters a fear of being wrong and reluctance to ‘give it a go’. We now know that mistakes in mathematics are very useful: they show that we are learning and they grow our brains. Yet, in contrast to this, many tasks are designed for students that give them work they will get correct.

Look at Nos. 2 and 7 of Setting up positive norms in maths class (Boaler, 2015). How might you use these at your site?

There are strong beliefs that you have to be fast at maths to be good at it, yet mathematicians think carefully and deeply about mathematics. Laurent Schwartz, a prize-winning mathematician, was one of the slowest thinkers in his maths class and says he felt unintelligent because his school valued fast thinkers. Teaching that values depth of thinking—rather than speed in mathematics—engages more students, in particular girls, and enhances brain connections (Seeley, 2009).

Look at No. 6 of Setting up positive norms in maths class (Boaler, 2015). How might you use this at your site?

What vision for learning mathematics do your teachers, parents and students have?

Do teachers in your site believe that everyone can learn maths? Do they have high expectations for all? In an experimental study of US high school classes, all students received critical diagnostic feedback from their teachers, but half the students received an extra sentence on the bottom of the feedback: ‘I am giving you this feedback because I believe in you’. A year later, the students who received the extra sentence achieved higher grades, not observed in the other group. This effect was significant for ‘students of colour’, who often felt less valued by their teachers (Cohen & Garcia, 2014).

Consider the Ontario Association for Mathematics Education Vision Statement in The principal as mathematics leader (Ontario Principals’ Council, 2009, p.78). Does it resonate with teachers at your site? Consider the ‘Observing and evaluating a mathematics classroom’ tool (idem, p.81). How might your staff use this tool to support and improve mathematics education in your site?
Resources

Brain plasticity
Video clip (5 mins)
http://www.youcubed.org/brain-science/
Professor Jo Boaler, Stanford University, presents an argument, supported by recent brain research, that challenges the belief that some people are good at maths and some are not.

Mathematical mindsets
A very readable book that includes chapters about the brain and learning maths; creating mathematical mindsets; rich tasks; the path to equity; and teaching maths for a growth mindset. Her one page handouts of her seven favourite messages for students (and others) are valuable resources.

Setting up positive norms in maths class
Jo Boaler, Stanford University
https://www.youcubed.org/positive-classroom-norms/
Jo Boaler’s seven favorite messages on setting positive classroom norms.

The principal as mathematics leader
Ontario Principals’ Council (2009) The principal as mathematics leader, California: Corwin Press (76 pages + principal resources)
An overview of how school administrators can start supporting mathematics education in their schools, along with advice about observing and evaluating classrooms, actions principals take, tools for success, and resources.

Advice for graduates

How to learn maths—for students
Jo Boaler, Stanford University
https://lagunita.stanford.edu/courses/Education/EDUC115-S/Spring2014/about
Free online class (also appropriate for teachers and parents). Students learn about their own math potential; strategies to learn and relate well to maths; the brain and math strategies and how to be more powerful in maths classes and in life!
3 sessions x 10 minutes
3 sessions x 20 minutes
NB There is also a more extensive fee-paying professional learning course for teachers and parents.

Beliefs and attitudes about mathematics/numeracy
https://www.edmodo.com/LeadingNumeracyImprovement (Group Code ncuifv)
A range of surveys for preschool, primary and secondary level students, teachers and parents to audit the beliefs and attitudes of your learners, educators and their community can be found at the Leading Numeracy Improvement Edmodo site.

Handout for parents: youcubed website
https://www.youcubed.org/handout-for-parents/
Six tips for parents to support their child’s mathematical learning, together with links to other youcubed parent resources.
References


Ontario Principals’ Council (2009) The principal as mathematics leader, California: Corwin Press

Perso T (2005) Improving Aboriginal numeracy, Adelaide: Australian Association of Mathematics Teachers


