WINNING SCOTLAND

CHILDREN AND YOUNG PEOPLE'S ATTITUDES TO MATHS

SCOTLAND 2022

HOW DO CHILDREN AND YOUNG PEOPLE IN SCOTLAND FEEL ABOUT MATHS AND WHY DOES IT MATTER?

At a Glance

In May 2022 we asked 6500 young people in Scotland how they feel about maths.

38%

feel more nervous about maths than any other subject

42%

think that some people are just born good at maths

57%

prefer to get a high score for something easy than a low score for something that challenged them

29%

don't think they are rewarded for showing effort and perseverance

45%

of secondary pupils believe it is important to not make mistakes in maths

40%

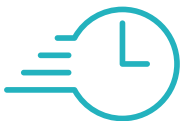
secondary school girls agree that when they find maths hard, they give up

54%

don't like solving really hard maths problems

18%

secondary school girls like to solve really hard maths problems



39%

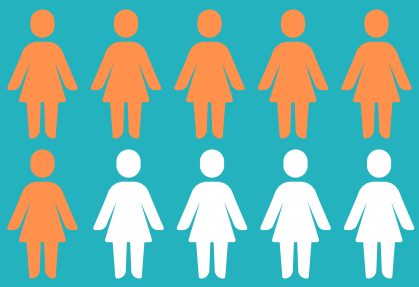
think it is important to be fast when answering a maths question

44%

feel nervous or anxious about maths

72% think people who really understand maths will get an answer quickly

6 out of 10 think intelligence remains fairly fixed throughout a person's life

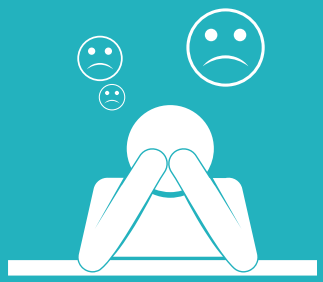


38

38% don't see the value in struggling when they find things difficult

51%

lose confidence when they make a mistake



33%

don't feel that they can use their creativity when learning maths

82%

believe they can be really good at maths

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INTRODUCTION

Scotland is a nation with a proud heritage and big ambitions. From building an economy with wellbeing at its heart to raising the attainment of every single child, Scotland, and it's people, need to move now to ensure that actions match the rhetoric.

> *"Every citizen holds Scotland's economic potential in their hands. Our economic growth and prosperity over many decades has been the result of entrepreneurial, talented and motivated workers in every sector, geography and demographic working in a culture that rewards and celebrates innovation and initiative.*
>
> *Our ambition for 2032 is for Scotland to be successful. Success means a strong economy where good, secure and well-paid jobs and growing businesses have driven a significant reduction in poverty and, in particular, child poverty.*
>
> *It means a society in which everyone can participate in economic success, in every community and in every region." (National Strategy for Economic Tranformation, 2022)*

Winning Scotland works with partners across the country to help people, particularly children and young people, achieve their potential. Our focus is, and has always been, on creating practical and tangible changes. From working with 30,000 sports coaches, parents and volunteers, to supporting 1299 teachers through masters level training on cultivating and nurturing growth mindsets in the classroom, we know that moving from theory to practice, from aspiration to change requires top-down investment, genuine co-production and working beyond and across traditional silos.

Winning Scotland and Renfrewshire Council have worked in partnership and used growth mindset as an approach to complement existing approaches in Renfrewshire to improve pupil confidence, resilience and engagement in maths.

Find out more about this partnership by watching our case study video.

The National Economic Strategy is wide ranging, but a key pillar is building a skilled workforce, and while much of the detail of future jobs is unknown, we do know that flexibility, strategic thinking, data analysis and collaboration will be key to our ability to adapt and thrive. What people learn will come secondary to how they learn to learn, face challenges and adapt.

> *"Over the next 10 years, with the greater use of artificial intelligence, changes in the world of work, the decarbonisation of traditional industries and the emergence of new industries, skills requirements will change fundamentally.*
>
> *Digital, data, cyber security, creative and leadership skills are likely to be at a premium, whilst we know that the ability to collaborate and cooperate will be essential for the anticipated rise in caring roles and as technology replaces routine work and frees people to focus on the elements of human service that really matter to people.*
>
> *The precise shape of the changes are difficult to predict, but we do know that people will need to be adaptable and flexible." (The National Economic Strategy, Scottish Government, 2022).*

This move from learning being viewed as amassing a collection of technical skills and practices, to a more in-depth, nuanced understanding of the broader tools and mindsets our children and young people will need to thrive, requires boldness, creativity and joined up thinking. Educators across the country are already engaged in this work and they must be supported to both build and share evidence of what is already working, and to foster innovation.

We must consider the culture of individual classrooms and schools, and the local environment in which they exist. And collectively, as a country and a culture, we must ensure that we are setting our children and young people – from every background – up for success, whatever that means to them.

This report may raise as many questions as it does suggest solutions. Its contribution to the ongoing conversation is based on feedback from almost 6500 school pupils across Scotland.

Our perspective, from the intersection between young people, teachers, charities and businesses, is intended as a supportive but challenging contribution to the ongoing conversation around our education system, and how we better prepare our young people for the challenges of the future.

THE VOICE OF CHILDREN & YOUNG PEOPLE

IN THIS PAPER, WE WILL CENTRE THE VOICE OF CHILDREN AND YOUNG PEOPLE, DENOTING OUR MAY 2022 SURVEY RESULTS LIKE THIS.

In May 2022 we engaged, via online surveys, with nearly 6500 school pupils from across Scotland to better understand their attitudes to learning, mistakes and challenge, particularly in relation to maths. We heard from pupils from 30 local authority areas*.

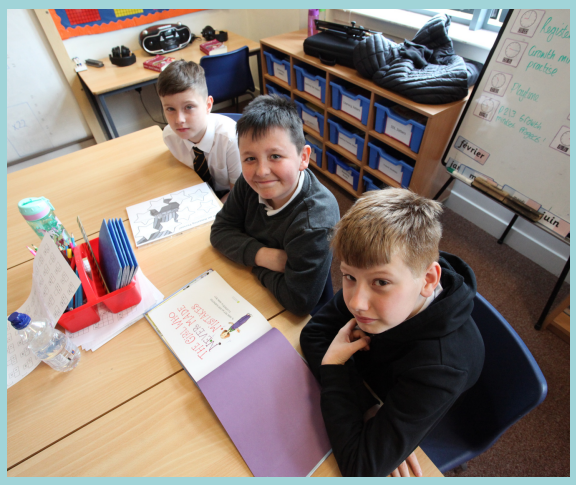
This paper puts the voice of children and young people in the context of academic research, and our own evidence from the many hundreds of teachers and school leaders we support through our CPD provision, to move the conversation on, bring together potential new approaches, raise questions and empower those on the front line of maths education to make the changes they feel are required.

We will discuss what the results mean, why they matter and - based on scientific evidence, strategies proven to be effective elsewhere, and advice from experts in the field of mathematics and numeracy – what improvements might look like.

* Responses from seven of the 30 local authorities had a much higher representation than the rest which should be taken into account when interpreting and discussing the findings. There are 796,300 pupils in Scotland.

With thanks to our local authority partners, this report contains representation from:

6412 pupils
3102 girls, 3065 boys, 98 non-conforming, and 147 preferring not to say
3266 secondary pupils, 3146 primary pupils



WHY MATHS?

Over the past eight years, we have worked with teachers and education leaders across Scotland and, while our approach is cross curricular, by far the most significant interest in our work comes from maths teachers and numeracy leads.

Maths is a subject that divides – for some it induces panic and fear; others believe there are 'maths people' and those without a 'maths brain'. The correlation between attitudes to maths, particularly maths anxiety, and academic performance is clear, both anecdotally and in research, as explored below.

Some of these attitudes and beliefs are known to be harmful, stifling achievement and impacting effort. They often have a more significant impact on girls.
Every subject area is important, but maths is recognised as being an underpinning component of success in many other subjects, specifically STEM. And beyond school, maths skills are required for 70% of current jobs (Budd, 2019). This is likely to grow as technology continues to advance and new jobs not yet in existence are created. As The Vorderman Report 2011 states, "not only is mathematics the language by which the sciences, commerce, the internet and the global economics structure all communicate, it is also an essential part of all of our personal and working lives."

Having a sound mathematical knowledge and understanding of numeracy are essential in terms of employability (Bynner & Parsons, 2001) and as key life skills (Gazal et al. 2014), like "applying for a mortgage, balancing the family budget, reading a bus time table, planning the family holiday, moving furniture, driving a car and even going shopping and working out the best buys in the shops." (Budd, 2019). A robust and confident approach to maths is therefore not just important for school, but for the rest of our lives as well.

THE SCOTTISH CONTEXT

The Scottish Government have prioritised the teaching and learning of mathematics and numeracy. For example, the focus of the 'Making Maths Count' initiative was to help transform Scotland into a maths positive nation by, "1. Transforming public attitudes to maths, 2. Improving confidence and fluency in maths for children, young people, parents and all those who deliver maths education to raise attainment and achievement, 3. Promoting the value of maths as an essential skill for every career" (Scottish Government, 2016).

While there has been some solid progress towards this so far, our survey of young people's attitudes to maths from May 2022 suggests that a significant percentage of Scottish pupils still have negative feelings towards maths:

44% FEEL NERVOUS OR ANXIOUS ABOUT MATHS

38% FEEL MORE ANXIOUS ABOUT MATHS THAN ANY OTHER SUBJECT

In schools, the Curriculum for Excellence (CfE) was developed to help "our children and young people gain the knowledge, skills and attributes needed for life in the 21st century" (Education Scotland, 2019). The purpose of the CfE is to help young people become "successful learners, confident individuals, responsible citizens and effective contributors".

While there is much to recommend from the CfE, there is increasing awareness that the focus on performance over the learning process in secondary schools runs counter to the stated aims and ambition of the approach:

> *"Early policy developments showed promise to align student assessment, qualification practices and system evaluation to CfE's philosophy. The 2010 Framework for Assessment was hailed internationally as an exemplar. Despite attempts to reform qualifications, misalignment between CfE's aspirations and the qualification system became a barrier to CfE's implementation in secondary education. Additionally, the data generated by current system monitoring seem limited to fully support CfE's ambitions " (OECD, 2021).*

The Scottish Government have since responded to this OECD report and its recommendations with a review of the current education system, including qualifications and assessment commissioned.

And when children ask their parents for help with maths homework?

A poll conducted by the Maths Anxiety Trust found that 1 in 5 adults in Great Britain feel "anxious when confronted with a mathematical problem, e.g. using mental arithmetic to split a restaurant bill."

Furthermore, results from the Making Maths Count focus groups revealed some adults "lacked confidence in their own skills and found it difficult to access the help they needed. Others were unsure about how maths is currently taught in schools and worried about confusing their children by showing them the 'wrong' methods: 'Parents can be nervous about trying to help in case they are teaching them something in a way which conflicts with how they're doing it at school.' Some reflected upon their own experiences at school and how this created problems for them in helping their own children: 'The maths department at my school was scary. I didn't like maths. Still don't like maths.'"

WHAT IS MATHS ANXIETY?

Maths anxiety is a “negative emotional reaction to mathematics, leading to varying degrees of helplessness, panic and mental disorganisation that arise among some people when faced with a mathematical problem, either in ordinary life or in an academic situation,” (The Maths Anxiety Trust). Maths anxiety is a serious and complex issue that can affect brain functionality, connectivity and even brain structure (Kucian et al., 2018). It can therefore affect learning and performance (Villamizar Acevedo et al. 2020).

It's associated with hyperactivity in the brain regions that are associated with negative emotion processing, and with reduced activity in parts of the brain involved in mathematical reasoning (Young et al. 2012; Supekar et al., 2015), meaning maths anxiety can alter brain functionality and connectivity, thus inhibiting the brain from being able to solve maths problems, regardless of ability. Put simply, when in a state of anxiety, brain resources are fully focused on the emotional response, meaning learning is almost impossible.

The effect of maths anxiety is far reaching. Studies have shown maths anxiety can affect achievement in maths (Barroso et al. 2021; Zakaria et al., 2012), as well as its influence on financial literacy (Skagerlund et al., 2018).

There is also a vicious circle when it comes to maths anxiety and poor maths achievement whereby “prior low levels of math achievement might promote the development of math anxiety and avoidance behaviour towards mathematics, resulting in even lower math skills.” (Kucian et al., 2018).

GIRLS (44%) FEEL MORE NERVOUS/ANXIOUS ABOUT MATHS THAN ANY OTHER SUBJECT COMPARED TO BOYS (31%)

The girls who responded to our survey report greater maths anxiety than boys, which is in line with other research (Hill et al., 2016). Even when girls attain as well as boys academically, they may still hold greater negative self-concept about their maths ability (Parker, Van Zanden, & Parker, 2017; Herbert & Stipek, 2005). This might partially be attributed to cultural stereotypes relating to gender differences, such as the widespread belief that boys are better at maths than girls (Cvencek, Meltzoff & Greenwald, 2011).

That girls are more likely to doubt their ability in maths has far reaching consequences, including less likelihood of them pursuing a career in a STEM-related fields (Seo et al., 2019). However, the same study also showed that children and young people with a well-developed growth mindset – who use strategies like focused effort, learning from mistakes and creative problem solving - tend to be confident in mathematics, regardless of their gender. Therefore, a promising way to increase maths confidence is to embed growth mindset in school cultures.

This finding is supported by the wealth of anecdotal evidence supplied by teachers participating in Winning Scotland's 'Mindset in Education' programme, like this example from Andrea Skene, an S3 biology teacher in North Ayrshire:

Growth mindset is more than a tick-box exercise

THE ROLE OF THE TEACHER

Several studies found that the teacher's own level of maths anxiety can influence pupil attitudes, particularly for girls if the teacher is also female (Beilock et al. 2010). It is worth noting that of the 53,581 teachers in Scotland (excluding early years), 89% of primary school teachers and 65% of secondary teachers are female (Scottish Government, 2021).

Lau et al. 2021 revealed that the strongest individual level predictor for maths anxiety is students' perception of teacher competence. They stress the importance of the role of the teacher when dealing with such a complicated issue like maths anxiety, and "suggest that the improvement of both instructional quality and teacher confidence may be potential avenues of reducing student anxiety." This is supported by our own evidence with 79% of the teachers who completed Winning Scotland's Mindset in Education course stating they feel the course will make them a better teacher.

Kiara Sim, a teacher from Isobel Mair school in Renfrewshire shared: "this course [Mindset in Education] really changed my perception of maths and that enabled me to change the learners' perception of maths too." See more in the case study linked below:

Pupils learn to love maths after growth mindset lessons (winningscotland.org)

THE ROLE OF THE PARENT

Parents also play an important role in their children's education. Gonzalez-DeHass et al. (2005) found positive parental involvement impacts "school engagement, intrinsic/extrinsic motivation, perceived competence, perceived control, self-regulation, mastery goal orientation and motivation to read."

Other research suggests a parent's own attitude to maths not only impacts their children's maths anxiety and attitude to the subject, but may also have an influence on achievement too (Soni & Kumari, 2017). Stolpa (2004) discusses how parents may unintentionally contribute to maths anxiety in their children by saying things like "Don't worry, I've never understood fractions" or "Never mind, maths was always tricky for me at school too", leading some children to believe that they are not capable of learning maths (Whyte & Anthony, 2012). Such influence is not just restricted to pupils who struggle with maths, Berstein et al. (1995) suggest parental pressure for success may increase maths anxiety in high achieving pupils.

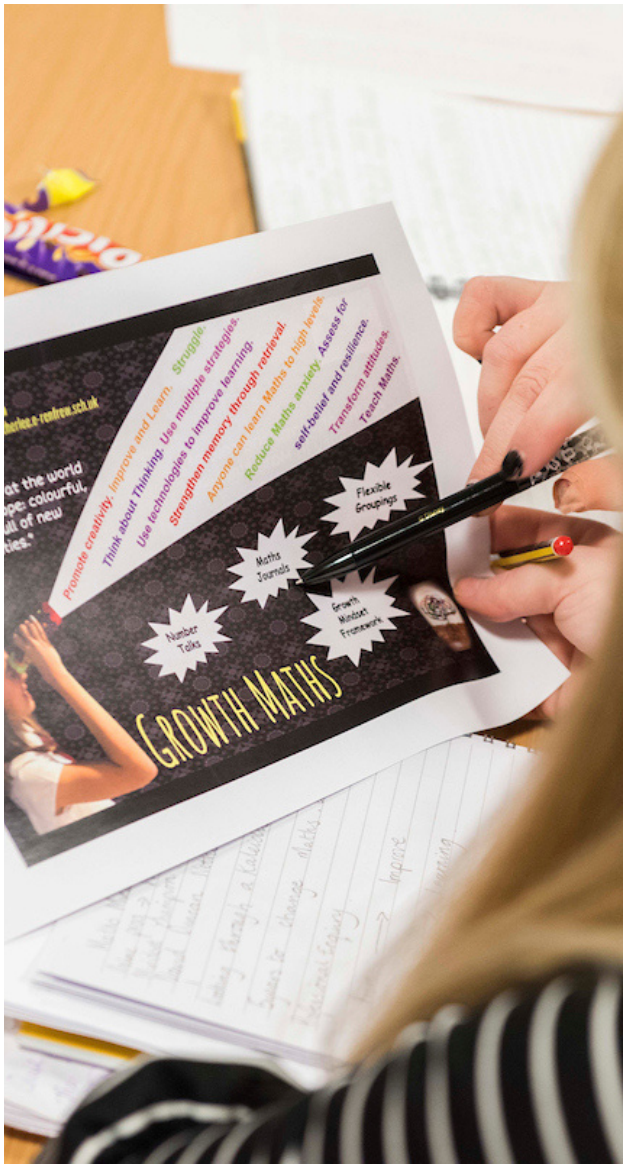
While another study by Maloney et al. (2015) also found parental maths anxiety influenced children's maths anxiety and learning of maths, their research showed that this was only relevant if a maths anxious parent frequently helped their children with maths homework. They suggest lack of maths helping skills and using instructional strategies different to ones used in school may be to blame, resulting in confused children who feel unable to learn and who may have picked up on their parents' negative feelings about maths. Thus, although well intentioned, some parental involvement can actually have a negative effect, if the right supports are not in place, or if parents hold a negative opinion of maths.

Promisingly, adult maths anxiety can be reduced. For example, Park et al. (2014) found that the use of expressive writing helped maths anxious university students to reduce their anxiety and boost their maths' performance.

Maloney et al. (2015) suggest implementing interventions to both decrease parents' maths anxiety and strengthen their skills in helping with homework, for example through structured activities that promote positive maths interactions between parent and child, like playing board games, doing online maths apps or watching video models of effective maths-homework help.

THE ROLE OF PEERS

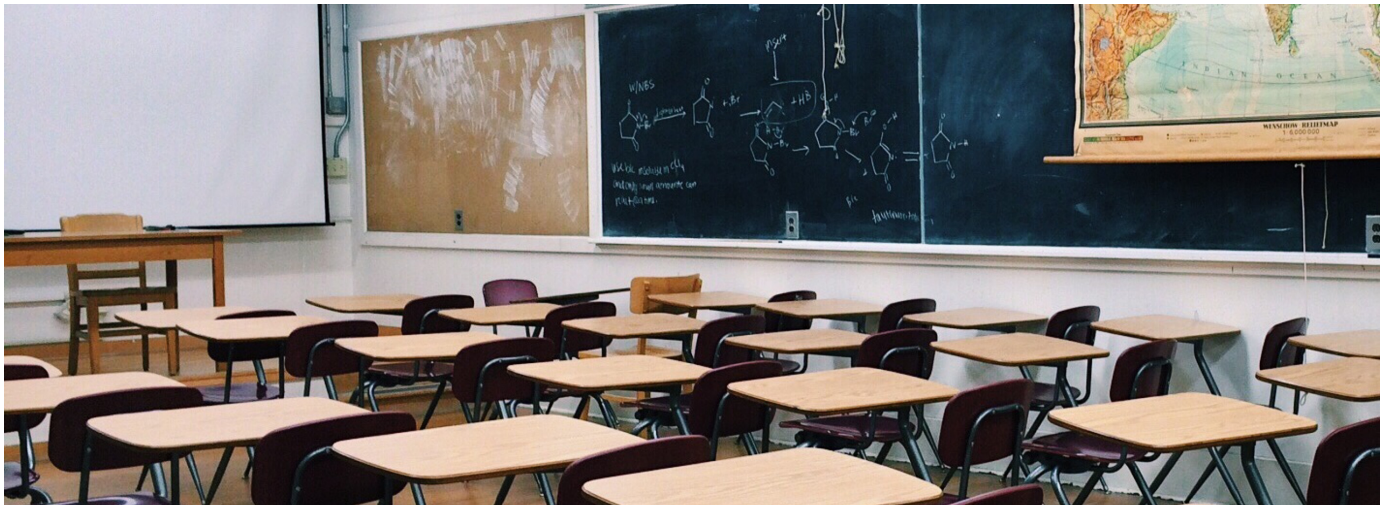
While the role of teachers and parents are key, peers are also really important. Research by King (2019) revealed that mindsets in the classroom are contagious. The overall class mindset has a direct influence on the pupil's own mindset which further highlights the importance of creating a safe, nurturing classroom and developing pupils' self-belief.



The social contagion effect of mindset and the impact this can have on classes and collaboration can be seen in the quote below from one of the teachers who completed Winning Scotland's 'Mindset Teams' course:

"My observations during juggling practice included children interacting positively, offering praise and engagement to each other. They looked to each other for technique input and were keen to pass their learning on.

Collaboration has always been an issue for this class. At the beginning of the year we moved the children from groups of four to pairs because they found it difficult to work together productively. They are now sitting in groups of up to six successfully."



MATHS MYTHS

Myths around speed of response and believing that there is only one way to reach an answer in maths can exacerbate maths anxiety, stifle creativity and cause young people to feel like they are not good at the subject.

68% OF PUPILS BELIEVE THERE IS A RIGHT AND WRONG WAY TO GET AN ANSWER IN MATHS

73% OF PUPILS BELIEVE PEOPLE WHO UNDERSTAND MATHS WILL GET THE ANSWER QUICKLY

34% OF SECONDARY PUPILS THINK IT'S IMPORTANT TO BE FAST WHEN ANSWERING A MATHS QUESTION

While an average of 27% of the pupils agreed that 'It is important to be fast when answering a maths question', this was higher for secondary school (34%) than for primary (21%), potentially due to the greater emphasis on exams and timed settings in secondary school.

Stanford University Professor of Mathematics, Dr. Jo Boaler and co-founder and Executive Director of 'youcubed' Cathy Williams, describe the importance of showing pupils the different ways to think about maths. Opening up mathematical content allows pupils to explore concepts more fully while trying different approaches and collaborating with peers allows for varied discussions, seeing things from a different point of view and a more in-depth understanding. They state, "it is essential to open tasks so that they [pupils] have space inside them for learning. When students see fixed content—short questions with one answer—they do not see how they can grow and learn." (Boaler & Williams, 2019). They highlight two approaches to maths:

TWO FORMS OF MATHEMATICS

Performance Mathematics	Mathematics Freedom
Repeat a method shown by the teacher	Consider a problem - what mathematical idea could you use to solve it?
Practice with similar questions	What connections are there between ideas
You will be judged according to how quickly and accurately you reproduce the methods	What new questions can I pose?

Boaler and Williams Two Forms of Mathematics

ASSESSMENT

Teachers clearly understand the importance of the learning process, ensuring pupils develop a deep understanding of concepts and topics, and that they are prepared for life beyond school. However, as highlighted earlier in this paper, the current education system strongly rewards end results and percentage scores, sometimes at the expense of deep learning, and attainment for all pupils.

We regularly ask teachers completing our programmes to share their views of assessment and how current processes aid or inhibit their pedagogy. Almost half of secondary teachers from the most recent pre-survey believed it is more important to pass the exam than to fully understand the subject. While this drops to 18% following completion of the Mindset in Education course, the pre-course level is likely indicative of perceptions across the wider teaching profession in Scotland.

46% of secondary teachers believe it is more important to pass the exam than fully understand the subject

While the system can necessitate teaching to 'pass the exam' previous research has shown that doing so can contribute to myths around maths, adding to the pressures pupils face, in turn contributing to maths anxiety (Whyte & Anthony, 2012).

> *"Assessment is an integral part of learning and teaching. It helps to provide a picture of a child's or young person's progress and achievements and to identify next steps in learning." (Scottish Government, 2011).*

How, then, do we balance the need to assess progress and performance with our understanding of how the current approach is leading to anxiety for some teachers and pupils, and ironically impacting on achievement?

While Scotland's current assessments are not as rigid as in some other systems (for example, Scotland looks at a wide breadth and depth of knowledge and tends to use tools for assessing progress along the way rather than as a one-off future predictor), some forms of assessment are still described by the OECD as "barrier(s) to CfE's implementation in secondary education", as they are more in line with performance mathematics.

The Scottish Government have already responded to this OECD 2021 report and its recommendations, saying that "commitments to move the role of inspection out of Education Scotland, to replace the SQA, and consider the implications of a new specialist agency responsible for both curriculum and assessment" will be a focus going forward (Scottish Government, 2022).

Professor Ken Muir was appointed as Independent Advisor on Education Reform in August 2021 to help advise on these commitments and provide "recommendations on how the features of the education system relating to curriculum, assessment, qualifications, support and improvement might best be reconfigured to promote and enhance excellence and equity." (Scottish Government, 2022).

Professor Muir compiled a report based on his consultations into this work and has provided 21 recommendations that he believes "would create a more cohesive, simplified and consistent education system to continue delivering excellence and equity for Scotland's learners." (Scottish Government 2022). One of the important principles set out in Professor Muir's report states that we should review "the roles and purposes of assessment, including examinations. Assessment should support progression in young people's learning and ensure that what we value in all learning is truly recognised through, for example, the enhanced use of the Scottish Credit and Qualifications Framework (SCQF)." Another key principle mentioned in Professor Muir's report was around creating an education system "where learners' voices, experiences, perspectives and rights are central to decision making."

Given the importance placed on pupil voice, keeping the young person at the centre of decisions that affect them, and embedding their rights within our education system in accordance with UNCRC, it is important we take into account their views on assessment and grading too.

9 out of 10 pupils who took part in the Maths Attitudes survey **expressed a preference that effort be given serious consideration when assessing pupils' performance.** This might allow recognition of a young person's capacity for learning and improvement as well as their current understanding of technical proficiencies.

FACING THE FUTURE

The challenges outlined are real and entrenched, but not impossible to overcome. There are examples of excellence across Scotland and beyond with education professionals, school leaders and teachers all working to change the status quo in our classrooms.

The impact of the Covid-19 pandemic led the government to cancel traditional assessments and the SQA to create an alternative assessment delivery, the 'Alternative Certification Model' (ACM) for use during this time. The ACM was created with the best of intentions and was designed to be fair and flexible, based on teacher judgements and supported by evidence. Unfortunately, the intentions did not match the reality for many pupils and teachers and many found it to be stressful and anxiety provoking.

Now is the opportune time to reflect on the function and delivery of maths education to ensure that more young people are able to embrace and thrive in the classroom.

MINDSET, SELF-BELIEF AND SELF-EFFICACY

Psychologist Albert Bandura defines self-efficacy as "people's beliefs about their capabilities to produce designated levels of performance that exercise influence over events that affect their lives. Self-efficacy beliefs determine how people feel, think, motivate themselves and behave." (Bandura, 1994).

93% OF PUPILS UNDERSTAND THAT THEY MUST WORK HARD AND APPLY EFFORT TO ACHIEVE IMPROVEMENTS

Positive self-belief has been linked to higher achievement (Valentine et al., 2004) and some researchers suggest beliefs about one's ability can influence later career choices (Lent et al. 2002).

82% OF PUPILS BELIEVE THEY CAN BE REALLY GOOD AT MATHS

When broken down by gender, this again was higher for boys (86%) than girls (80%), and for primary (86%) compared to secondary school pupils (79%), which supports previous research which found teenage girls tend to report greater negative maths self-concept than boys (Cvencek et al., 2011).

WHEN I DON'T DO WELL IN MATHS IT MEANS I'M NOT VERY GOOD AT IT

TOTAL

BOYS 49% GIRLS 62%

PRIMARY 42% SECONDARY 66%

Over half of the pupils surveyed **(56%)** reported **feeling like they are not very good at maths when they don't do well in it.** Again, more girls **(62%)** than boys **(49%)** felt this way. Seo et al. (2019) propose such gender differences might be linked to how girls "attribute their struggles in math to lack of innate ability rather than effort."

Secondary pupils **(66%)** were also more likely to agree than primary pupils **(42%)**.

SOME PEOPLE ARE JUST BORN GOOD AT MATHS

TOTAL

PRIMARY 36% SECONDARY49%

With regards to innate ability 43% of pupils agree 'some people are just born good at maths'. This view is similar for boys (43%) and girls (42%) but similar to other responses, secondary pupils (49%) were more likely to agree with this statement than primary school (36%).

Research shows that growth mindset, "the belief that your basic qualities are things you can cultivate through your efforts, your strategies, and help from others" (Dweck, 2017) can influence peoples' self-belief, as they see effective effort and perseverance rather than innate ability as being key to their improved performance (Stump et al., 2014).

An example of growth mindset strategies being used in Early Years, which is a key time for child development, to help improve attitudes to maths and foster self-belief can be seen from the inspiring case study from Forehill Early Years Centre in South Ayrshire:

Mindset builds confidence in early years (winningscotland.org)

DEVELOPING MASTERY

Mastery has been defined as "a focus on developing one's abilities, mastering a new skill, trying to accomplish something challenging, and trying to understand learning materials. Success is evaluated in terms of self-improvement, and students derive satisfaction from the inherent qualities of the task, such as its interest and challenge." (Meece et al., 2006).

In contrast, a performance focus is about "demonstrating high ability relative to others, striving to be better than others, and using social comparison standards to make judgments of ability and performance. A sense of accomplishment is derived from doing better than others and surpassing normative performance standards."

Meece et al. (2006) suggest that pupils "show the most positive motivation and learning patterns when their school settings emphasize mastery, understanding, and improving skills and knowledge. Whereas school environments that are focused on demonstrating high ability and competing for grades can increase the academic performance of some students, research suggests that many young people experience diminished motivation under these conditions."

Winning Scotland's work with Scottish businesses suggest that the mastery approach more effectively develops the skills and attitudes required by employers, and is increasingly seen as essential to capitalise on success in the workplace.

Further research has revealed positive links between a mastery approach and perceptions of academic ability and self-efficacy (Wolters 2004). While a mastery approach has not been directly related to academic performance consistently, evidence has suggested that a mastery approach may influence performance through the greater self-belief associated with it (Roeser et al. 1996), or through more in-depth processing strategies (Grant & Dweck 2003). Grant & Dweck found that a mastery approach was more likely to lead to improved performance outcomes when there is a large degree of challenge, when processing of complex material is required, or when the learning itself is of great personal value.

It is important that our policies recognise the importance of mastery, and that our learning environments allow space for such approaches. Our classrooms and schools need to be places where pupils can see mastery is valued and encouraged. If we focus on mastery and help to build self-efficacy and self-belief at the same time, there is evidence to suggest the success and high levels of achievement we desire for our young people will follow, while also allowing for the skills and attributes required for the future world of work to develop, skills such as resilience, problem-solving, and tackling challenges with enthusiasm.

CREATIVITY AND CURIOSITY

Lack of freedom in maths and an over-reliance on performance focused maths can also affect creativity and curiosity, which are essential for problem-posing and problem-solving.

I CAN USE MY CREATIVITY WHEN LEARNING MATHS

TOTAL

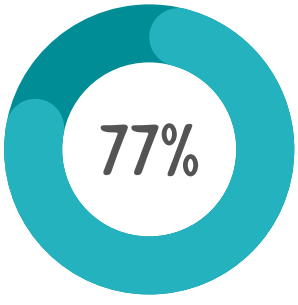
SECONDARY 50% | PRIMARY 76%

It is promising that overall, 63% of the students surveyed feel they can use their creativity when learning maths. However, there is a sizeable divide when you look at this in terms of primary (76%) vs secondary school (only 50%). This may be connected to the greater emphasis on exams and timed tests in secondary school, when compared to primary.

Dr. Robert Sternberg, professor of human development at Cornell University points out, "you don't need them [creative skills] to be successful in school." In fact, there is no incentive to be creative, "so kids won't be" (Isenberg, 2015).

However, it is recognised that meaningful and high paying jobs will require a degree of creativity, for example in problem-solving and innovation. Deloitte's 'Future of Work' series describes the jobs of the future as likely to "be more machine-powered and data-driven than in the past, but they will also likely require human skills in areas such as problem-solving, communication, listening, interpretation and design." (Schwartz et al. 2019).

MATHS IS A SUBJECT THAT CONNECTS LOTS OF IDEAS TOGETHER



TOTAL

SECONDARY 71% | PRIMARY 84%

It is positive to see so many pupils view maths as a subject in which they can connect ideas and concepts. However, there is yet again a difference between primary (84%) and secondary (71%) responses. This could in part be due to the difference in teaching of maths across the sectors but also due to the greater emphasis on exams and teaching to the test in secondary, which may not allow for as much time for the exploration of connections between ideas.

In 'Developing Mathematical Mindsets', Dr Jo Boaler describes how for many children the natural curiosity they once had for maths is quashed during formal education, by them now viewing maths as being all about "following instructions and rules" (Boaler, 2018-2019), and essentially losing the creative aspect which enables connections to be made. Boaler explains that this is partly down to how parents and teachers view maths - because some areas of maths are factual, some parents and teachers believe they "need to be learned through mindless practice and speed drills. It is this approach to early learning about numbers that causes damage to students, makes them think that being successful at math is about recalling facts at speed, and pushes them onto a procedural pathway that works against their development of a mathematical mindset."

Boaler explains the importance of developing 'mathematical mindsets' to help pupils to develop the motivation to understand maths and numeracy on a deeper level, to think about it, question it and explore it, to feel confident that they can make sense of it, and to understand maths "is a subject of growth and that their role is to learn and think about new ideas."

Boaler and Williams provide some suggestions for how to create mathematical freedom within the classroom. They suggest using open rather than close-ended questions, using and encouraging visual representations, and encouraging pupils to seek patterns and use reasoning (Boaler & Williams, 2019). See below for an example (more available at youcubed.org.)

EXAMPLE: CLOSED VD OPEN QUESTIONING

Closed: Find the area of a 4 inch. by 6 inch. rectangle.
Open: How many different rectangles can you draw with an area of 24 square inches?
Watch pupils describing their changing attitude to maths working in the 'freedom' mathematics style: **Math Camp 2019 - YouCubed**

Boaler describes how, prior to starting school, children are given the freedom to play with puzzles, shapes and numbers, to look for patterns and spot relationships. She adds it is critical once children start school that teachers continue to allow for flexibility, creativity and exploration when teaching maths, to promote conceptual understanding of maths and avoid extinguishing the enthusiasm and natural curiosity children display towards maths and numeracy. The strategies and resources referred to in relation to 'freedom' mathematics allow for such creativity with regards to maths, and would help with developing number sense and conceptual understanding of maths.

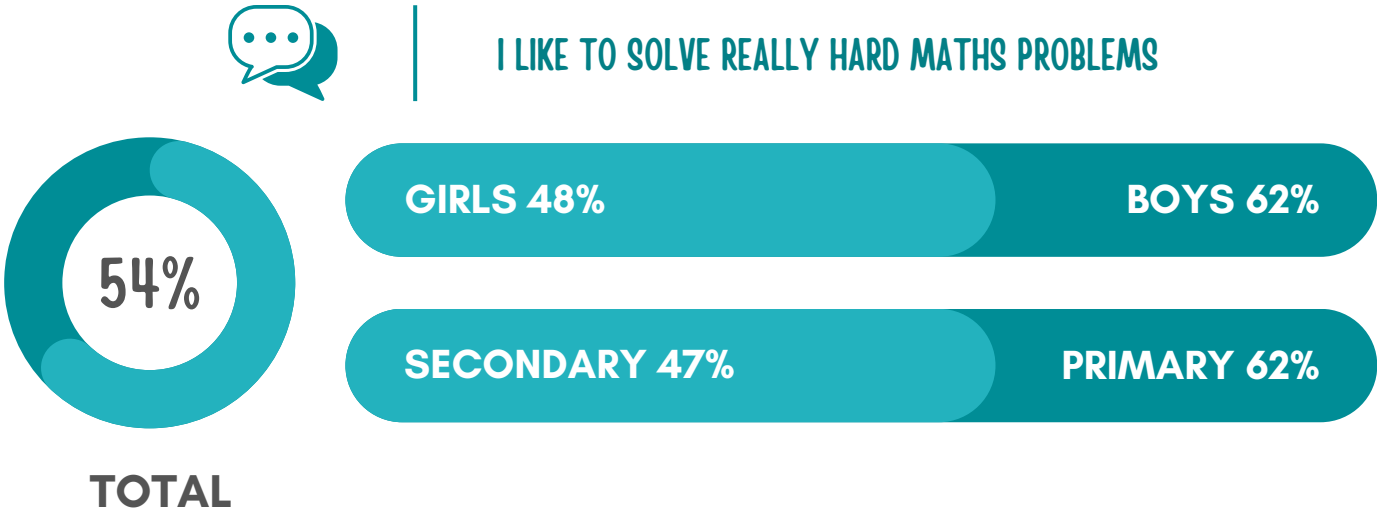
2014 Field Medal Winner, Manjul Bhargava describes the creative side of maths from a mathematician's point of view eloquently, "mathematics – like music, poetry, or painting—is a creative art. All these arts involve— and indeed require—a certain creative fire. They all strive to express truths that cannot be expressed in ordinary everyday language. And they all strive towards beauty" (Rajghatta, 2014).

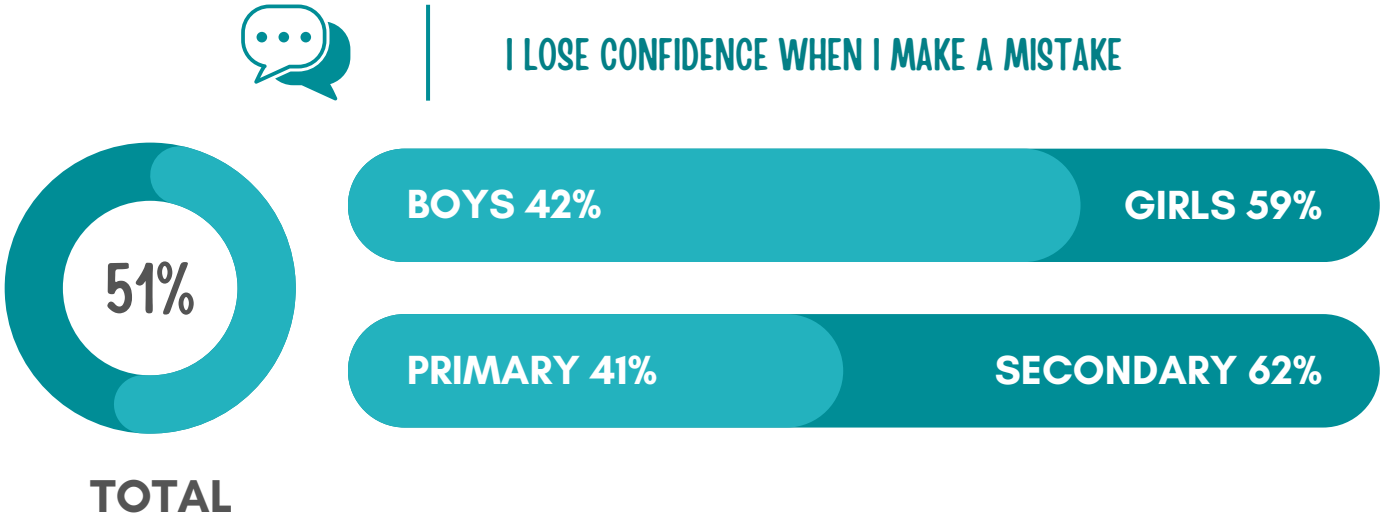
Bhargava along with many other experts in the field see creativity as an essential component to maths. We need to ensure our classrooms at all stages allow for maths creativity to flourish.

ATTITUDES TO CHALLENGE AND MAKING MISTAKE

Almost half **(46%)** of young people asked don't like to solve really hard maths problems.

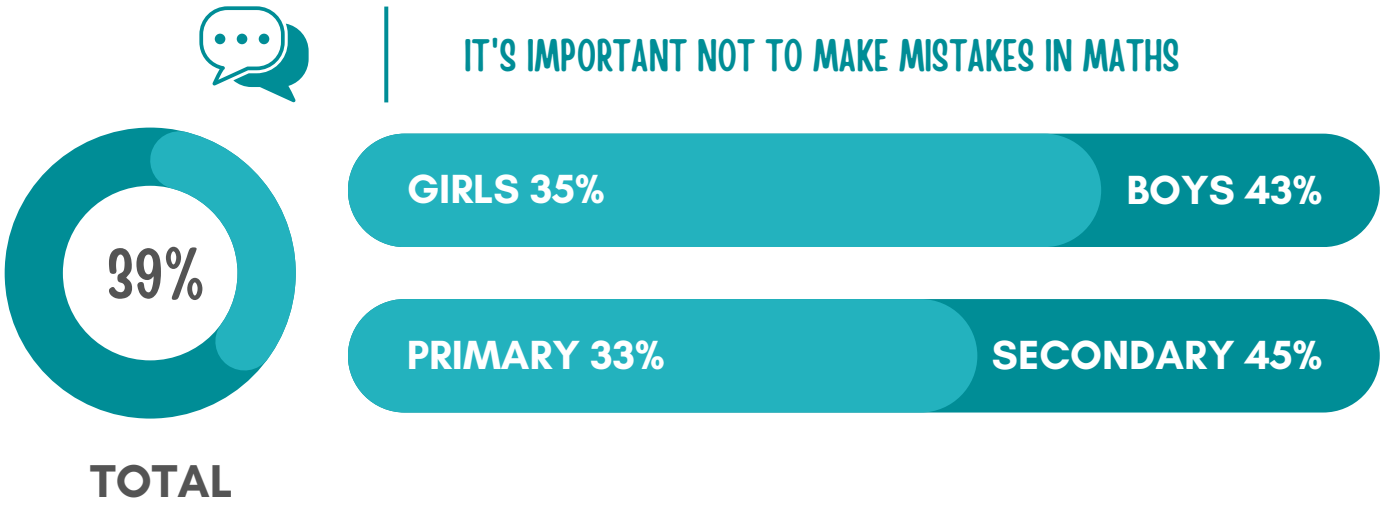
The breakdown shows more girls **(52%) disagreed** in some way **with the idea of enjoying solving really hard maths problems** compared to boys **(38%)**, as did secondary pupils **(53%)** compared to primary pupils **(38%)**.





Perhaps the fear of making mistakes contributes to some pupils not enjoying challenging maths problems.

1 in 2 pupils **(51%)** agreed that they **lose confidence when they make a mistake.** Similar to other response patterns, more girls **(59%)** than boys **(42%)** agreed with this statement, as did more secondary school pupils **(62%)** than primary pupils **(41%)**.



Added to this, **39%** of pupils **believe it is important not to make mistakes in maths.** Yet again, the percentage of pupils who agreed with this statement in some form was higher for secondary pupils **(45%)**, than it was for their primary **(33%)** peers. Interestingly however, and contrary to other responses, more boys **(43%)** compared to girls **(35%)** agreed with this statement.

Pupil and teacher attitudes to mistakes are important, given the vital role mistakes play in the learning process. Brain plasticity allows for new pathways in the brain to be created when we make mistakes, when we challenge our brains to learn new concepts and skills (Moser et al., 2011). Mistakes are essential if we are to learn and grow.

To learn more about what happens to our brains when we make mistakes and how we learn from this watch Professor Carol Dweck of Stanford University speak about this:

Watch the video

Clearly there are sloppy and careless mistakes that should be avoided but it's important that pupils realise the value of mistakes, how they impact their brain and contribute to deep learning. It is just as important that we create safe environments in which such mistakes can be made. A study by Steur et al. revealed that when pupils perceive their classroom as mistake- friendly spaces, they increased their effort in their work (Steur et al., 2013).

A teacher in North Lanarkshire who took part in Winning Scotland's Mindset in Education programme shared:

> *"At the beginning of my project, the general attitude of the school when it came to maths and problem solving was that of anxiety, nervousness, negativity and a major lack of enjoyment. Pupils were, "scared in case I don't get sums right", "worried I'll get all the answers wrong" and felt, "it's hard and I don't like it" and "problem solving is hard."*

> *"By the end of the project, when asked how they felt about maths and problem solving, the pupils were saying things like, "it's a challenge but I like it", "I feel a bit challenge d because I don't know everything about maths yet but I will try and learn it" and "I feel better about it but it's still a bit of a challenge." This was incredibly encouraging".*

EXPECTATIONS AND ABILITY GROUPS

'Setting' children into ability groups has supporters and detractors but the typical labels of low, middle and high ability can stick with learners for life, affecting their overall experience with school, hindering their self-esteem and limiting their beliefs in relation to their capabilities (Hamilton & O'Hara, 2011).

Hamilton & O'Hara, (2011) discuss the draw of ability grouping for many schools, due in a large part again to accountability measures and being heavily 'performance-focused'. They mention how "ability constructs in conjunction with accountability built around high-stakes testing powerfully seduces the practices within schools into forms of ability grouping." They also refer to the tension that is created by this in countries like Scotland whose agenda is largely focused on equity. They state that "the tension that might exist between the egalitarian beliefs held about the system and reform which represents subservience to a culture of performativity and accountability" is rarely discussed. However, it is due serious consideration if we are to truly create an equitable education system for all of Scotland's young people.

Evidence from Finland which has a policy of only using mixed-ability groupings has one of the smallest gaps between 'lowest' and 'highest' achievers (OECD, 2007). This is very likely impacted by more than just mixed ability grouping but is worth noting.

A study by Francombe & Hewitt (2018) which looked at mathematics in relation to student beliefs, teacher beliefs and practices found that students' perceptions of how math classes were taught varied depending on whether they attended school M (mixed ability) or school S (used setting). Students in school M perceived typical maths lessons as involving problem solving or collaborative challenge work in pairs/small groups and having several entry points, whereas students in school S perceived maths as procedures delivered by teachers and replicated by pupils.

Interestingly, teachers' perceptions regarding maths teaching differed compared to students' perceptions, but only for school S, which uses setting. Despite teachers from both schools holding similar views about mathematics and ways of teaching, the experiences of pupils from school S did not align with that. "Students within the classes which were set by "ability" had a different perspective on their lessons to those of their teachers. They experienced more of a transmission style of teaching with little opportunity for some ways of working which they valued, such as collaborative work and learning from their mistakes." Given the impact procedural, rigid maths teaching can have, as discussed earlier, the use of setting on pupils' experience of maths teaching and learning should be given serious consideration, and the views of pupils should be sought in relation to all of this.

Francombe & Hewitt (2018) revealed mixed attainment groupings involve more collaborative work and in-depth discussions than set groupings and a meta-analysis by Slavin et al. (2003) showed collaborative work benefits all pupils, regardless of 'ability', and helps improve academic achievement, motivation, and metacognition, among other things.

Such collaborative skills and discussion are valued in the workplace too (Tieman, 2012). As Nicky Binning, Head of Experienced Hire and Global Mobility at KPMG, the advisory firm puts it, “There is now such a pace of change that it almost doesn’t matter what you have done in the past,” …. “It is the ability to understand what is in front of you, and work collaboratively, that counts. You have to work together as a team because it is likely you are facing something you have never faced before.” (Tieman, 2012). Therefore, it makes sense to incorporate such skills more within the classroom.

Teachers’ beliefs about the nature of maths influences how they teach it too, including whether or not they feel maths is suited to mixed-attainment teaching. (Ireson & Hallam, 1999).

Mixed ability groupings are not without their challenges. They require more planning and complex instructional delivery on the part of the teacher. Gamoran 2002 stresses the importance of ensuring that mixed ability classes allow for all students to feel challenged and have high expectations for all pupils. The most important factor when it comes to ability grouping or setting may be teacher attitudes and instructional methods, rather than on the type of grouping per se. Boaler encourages whole class ‘low floor high ceiling’ tasks to allow all children to find their ‘stretch’ zone and feel challenged without feeling overwhelmed.

Teachers who took part in Winning Scotland’s Mindset in Education programme showed a shift in attitude towards their pupils’ ability to improve, based on pre and post survey results.

BEFORE THE COURSE, **51%** OF TEACHERS AGREED THAT ALL OF THEIR STUDENTS WOULD IMPROVE THEIR ABILITY IF THEY WORKED HARD AT IT. **POST COURSE THIS INCREASED TO 93%**

BEFORE THE COURSE, **57%** OF TEACHERS THOUGHT THAT THERE WILL ALWAYS BE SOME PUPILS WHO DON'T 'GET IT' NO MATTER WHAT, **POST COURSE THIS DROPPED TO 13%**

DEPRIVATION

There is some evidence that ability groupings widen the attainment gap between the most disadvantaged and least disadvantaged pupils (Schofield, 2010), and exacerbate other inequities further (Gamoran, 2002). Due to wider societal inequalities affecting test scores among other things, pupils from lower socioeconomic backgrounds are usually placed in lower ability groups (Gamoran, 2002, Archer et al. 2018). Lower ability groups tend to be treated differently and not challenged to the same degree as those in other groupings (Schofield, 2010, Francis et al., 2017), thus adding a ceiling to their potential to achieve, due in part to difference in teacher perceptions regarding students' abilities (Hamilton & O'Hara, 2011).

To make matters worse, mobility between ability groups tends to be limited (Dunne et al. 2011, Wilkinson & Penney, 2014). This means that not only do pupils from lower socio-economic backgrounds tend to be placed in lower ability sets, due to low mobility between sets they are likely to stay there, where they will be given less challenge and opportunity for growth. To use educational leader, specialist and author, Adam Riches' words, "We must focus on how such approaches continue to create hierarchy and inequality within society. The "ability" part of ability setting is only the tip of the iceberg – the divisive nature of setting runs much deeper than we may think." (Riches, 2021).

Wider cultural effects are also at play with regards to socioeconomic status and achievement. An OECD report from 2004, which analysed PISA data from 2003, showed that "schools attended by advantaged students are themselves advantaged in a wide range of ways" (OECD, 2004), for example, socioeconomically advantaged schools "may have access to more and better resources" and more consistent staffing.

More recent OECD report from 2016 showed that while the quantity of maths education was the same across social groups, the quality varied significantly and that it wasn't just about resources. "While disadvantaged students tend to learn simple facts and figures and are exposed to simple applied mathematics problems, their privileged counterparts experience mathematics instruction that help them think like a mathematician, develop deep conceptual understanding and advanced mathematical reasoning skills." (OECD 2016) Additionally, teachers in advantaged schools were more likely to use cognitive activation strategies (e.g. presenting problems for which there is no obvious or single solution, giving problems that require an extended period of thinking time or asking students to apply their learning to different contexts) which correlate to higher levels of perseverance, a preference for maths over other subjects and seeing maths as more useful in their career (OECD 2016)

Teacher's beliefs around pupils' ability and their expectations of pupils have been shown to affect pupils' achievement (Rubie-Davies et al., 2014). They found that pupils of teachers who had been specifically trained in practices of high expectations had increased their maths scores over one year, equivalent to a 28% greater improvement, compared to the control group. Good & Nicholls, 2001 have discussed the role self-fulfilling prophecies have to play in all this – teachers who have high expectations of their pupils tend to interact with them in a way that leads to those expectations being reached.

To complicate matters further, the implicit beliefs teachers hold (unconscious bias) also affect how they treat their pupils and their expectations of pupil achievement (van den Bergh et al., 2010). Interestingly, some research has shown how implicit and explicit beliefs and expectations can differ by subject. Peterson et al. (2016) found that teacher's explicit expectations affected pupil performance in reading, but not in maths. However, teacher's unconscious bias impacted their pupils' maths achievement. Such studies highlight the complexities of the biases we all hold and the impact they can have. Serious consideration should be given to both given their influence in the classroom.

A study by Gray and O'Tall (1994) showed that pupils labelled as 'low achieving' by their teachers approached maths using learned procedures to try and solve the tasks at hand and stuck to these learned approaches even when to do so was hindering their progress, whereas the 'high achievers' used what is called 'number sense' to think about maths conceptually and flexibly, in order to solve the problems. The way in which the pupils approached the tasks caused a division in performance, which may have led the 'lower achieving' pupils to believe they are not good at maths, when in fact they were just using unhelpful strategies when compared to their 'high achieving' peers who approached things from a more conceptual standpoint. This is likely made worse by 'lower achieving' pupils often being "identified as struggling with math and therefore given more drill and practice—cementing their beliefs that math success means memorizing methods, not understanding and making sense of situations." (Boaler 2018-2019). It is a vicious cycle.

ALTERNATIVE ASSESSMENT

Professor Guy Claxton, honorary professor of education at University of Bristol, notes that the belief "that knowledge and skills cannot co-habit" is one that many people in education circles hold. The idea that "you cannot do knowledge and rigour and good grades, and at the same time, build those much-vaunted "21st century skill" is prevalent in the sector" (Claxton, 2020). Claxton goes on to say that "it is confusing enough for classroom teachers, most of whom would dearly love to be doing both. They know that grades are needed for access to tertiary education, for example, but that, once enrolled, students' success depends more on their ability to be resilient and self-organised learners.

School leaders, for their part, feel as if they are being forced to choose between making their school into an exam factory and producing well-rounded young people who do not have the grades."

Claxton dismisses the idea that knowledge and 21st century skills development cannot be achieved together. He provides examples of those doing this balancing act well, such as the 'expeditionary schools' in the US, the 'Isaac Newton Academy' in Ilford and 'XP school' in Doncaster. Each of these examples work on personal attributes and character, whilst also looking at real world issues that are relevant to the young people which helps engage them in their learning. In the case of the XP school, it involves "real-world issues and problems that students can relate to and invest in personally; they are packed with academic rigour, and are designed to cover many standards of the national curriculum in depth." (Claxton 2020). From Claxton's global research with colleagues, all examples of good practice who have got this balance between knowledge and skills right have done so "not through constant drilling and testing but the right way, through gradually building [pupils'] capability, confidence and appetite for taking charge of their own learning."

The intensity of lockdowns are hopefully behind us but the impact of Covid-19 will continue to be felt for years to come. Perhaps we can take inspiration from those examples of good practice and the concept of 'learning by doing', as well as from the commendable example of the Finnish education system, and add to the CfE, in order to enhance it further, in line with OECD recommendations. Now is an opportune time, then, whilst the Scottish Education system is undergoing reform, while we are still in recovery mode, to reconsider if our education system is best serving our young people and our society or not.

CONCLUSION AND QUESTIONS

This report has focused on pupils' responses from the 2022 Mindset Maths survey, to shed a light on young people's current attitudes to maths in Scotland, discuss why this matters, and importantly, what we can do to help improve things.

In many respects, the results from the survey were positive, suggesting that efforts put in so far by Scottish Government, Education Scotland, schools, teachers and others to help improve attitudes to maths are having a positive impact. However, it is also clear that maths anxiety remains an issue, although there are clear signs that interventions can be effective across both genders and all stages.

How can we come together to build on the work that's been done so far to improve how people feel about maths, so that young people feel more comfortable approaching maths challenges, and ultimately so that more young people are confident in maths, and STEM, opening the doors to new career opportunities?

Ensuring that we allow for mathematical freedom in our classrooms is a key component to enjoyment of maths, and thus a reduction in maths anxiety. Increasing self-belief of teachers and pupils with regards to maths will also help with this. Matching this with appropriate feedback, evaluation and monitoring systems can help to promote learning and achievement while also ensuring we can encourage young people to strive for mastery. This would need to be supported by including elements of mastery, effort and wider achievement as part of the assessment process. Looking at the individual learner journey and taking inspiration from successful, alternative assessment methods could help with this.

Scotland is on a journey to become a maths positive nation. The green shoots are showing.
The evidence is available. Government, educational organisations, schools, local authorities, parents, pupils and even businesses and charities can collaborate to accelerate progress for all.

Join the conversation. Email info@winningscotland.org to let us know what you think.

USEFUL LINKS

To find out more about how such work ties in with Mindset specific approaches to learning watch the case study below from Heriot Primary school:

Growth mindset helps dispel myths about maths

What is working in numeracy and maths (Education Scotland)?

Mastery Explained

Creative Approaches to Maths

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