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How can the learning relationships that work to develop Mathematical Resilience in mathematics classroom be characterised?

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I want to explore here a question that feels paramount to me in work to develop mathematical resilience. How can teaching and learning day-in, day-out to develop mathematical resilience be characterised? Working for mathematical resilience means developing a particular relationship in a classroom, one that cares for the students and one that cares for learning mathematics. I know that mathematical resilience is developed in environments where there is mutual warmth and respect, where learning is a mutual endeavour, where learners are encouraged to express their ideas and where everyone listens attentively, especially the teacher. It seems from recent research on the brain that the social is a vital part of the brain's work and that removing the social removes a vital form of support and motivation in learning. A classroom that offers care in learning mathematics (Watson,2021), is a social classroom and one which prioritises the well-being of students.

Keywords: Characteristics of learning and teaching; the social brain; care in teaching mathematics.

Introduction

In this paper I want to set out what is for me a research agenda. I feel that much is known about mathematical resilience, what the principles behind developing it are and why work to develop it is necessary, indeed vital. What I feel less is known about is what the basic characteristics are of a classroom where mathematical resilience is being developed. Without a vision of such a classroom, how can teachers work towards practice that increases mathematical resilience?

I have been able to define the mathematically resilient classroom in terms of the characteristics those who have mathematical resilience may be expected to display (Lee and Johnston-Wilder, 2024a) and the principles to which a classroom where mathematical resilience is likely to be developed will adhere (Lee and Johnston-Wilder 2024b). Work has been done to establish (e.g. Kooken et al., 2016, Hunt and Petronzi, 2024) that there are four factors to attend to when teaching mathematics with the intention to build resilience: growth, value, struggle and support. We also know that teaching for mathematical resilience is a way of thinking or possibly a set of principles; it is not a 'to-do' list and especially not a 'to-don't' list. Such teaching is certainly about ensuring the well-being of all actors in the classroom. As such, there are elements of social justice at play here, no-one is to be excluded or left behind because they lack the previous experiences that have allowed their peers to make progress with learning, appropriate support can and should be provided. It is also about recruitment and retention, it asks teachers to do what most teachers say they came into teaching to do, that is to care for their students and allow their understanding to grow. Taking such a stance makes what is a difficult job much more

rewarding than the ‘teach to the test’ stance that seems prevalent. Teaching for mathematical resilience is not about test results, although resilient learners take examinations as another obstacle to think their way through. It is about enabling students to approach mathematical ideas with positivity and to be able to continue to willingly engage with mathematical ideas, thinking and reasoning beyond school.

Teaching for mathematical resilience is about teaching mathematics without generating anxiety, and care for the learning of mathematics must be at its core. This means that alongside caring for students, mathematics teachers must also care about the mathematics they are teaching. The two must be intertwined. Such teachers must help learners to understand that learning mathematics can present barriers because of its nature whilst also inducting them into the intricacies and joys of thinking and reasoning mathematically.

It is not easy or straightforward to implement such teaching in ordinary classrooms, but it is possible. I am aware of teachers working in schools who enable their pupils to take pleasure in thinking mathematically and overcoming the barriers that learning mathematics presents. They allow them to become resilient learners of mathematics. What I do not know is exactly should be in place in a classroom day in day out if the learners within that classroom are developing and growing mathematical resilience alongside learning and growing mathematical understanding. It seems to me that what is important is not what tools to use but rather how mathematical learning can be presented so that learners grow their understanding in an atmosphere of support and care for each individual’s learning and well-being.

Care and compassion and mathematical resilience

I have been considering the place of care and compassion within mathematics education for a while. It became clear to me that relationships within the classroom were of vital importance when I was reading the literature I required for my publication with John Morgan (Lee and Morgan, 2024). The teachers spoken about by the participants in that study did not form good relationships in their classrooms. They reacted to the participants’ lack of understanding of the mathematics being offered with a lack of comprehension of how anyone could not understand. If the teachers had cared about these participants surely their reaction would have curiosity, what is it that is preventing your understanding? The participants led us to understand that this lack of care from the teachers for the pupils in their classes may have been as a result of a lack of understanding of how to help. Several participants felt that their teachers had no idea what to do if their first explanation was ineffective. So, the care that they should have been able to show their pupils was inhibited because the teachers themselves did not know how to show care for mathematical understanding. It seems to me therefore that teachers who want their pupils to grow mathematical resilience alongside mathematical understanding must both care for their pupils and care for the mathematics they are teaching. Neither can take precedence.

Care for teaching mathematics

Anne Watson has written persuasively about what it means to care when teaching mathematics, making the point that “care for the students and care for the subject matter must be intertwined” (Watson, 2021, 83). She goes onto say:

This view posits mathematics as a shared task in which teacher and student focus together sometimes as equals; sometimes as expert-apprentice. In her image, the shared task is overtly mathematical, the ideas, methods and meanings are in the

classroom mathematical culture, the goal is mathematics learning and the actions are those of mutually caring about the mathematics.” (Watson, 2021, 84).

She sees the pedagogic relationship as happening between people, learning is not seen as transferred from one person to another, learning occurs in the joint focus the teacher and the student have on the object, in this case, the mathematics. Therefore, learning mathematics requires an intertwining of skills in showing care for students and care for mathematics. Only in this way can the teacher offer and encourage that shared focus on the mathematics to be learned and to care for the learners’ minds.

Care for learners’ minds requires teachers who listen, seek to understand what they say and how they think, and above all take concerns and successes seriously. Talking about mathematics with a more competent peer offers not only an induction into the technical language of mathematics and instruction in concepts and processes, but also offers ways in which representations may be visualised and manipulated. The shared conversations allow the monitoring of concept images as they are being constructed, allowing appropriate adaptation of further conversations and tasks accordingly. “Language and listening in the midst of mathematical opportunities are the mechanisms by which care for mathematics and care for learning are fused into care for the learning of mathematics.” (Watson, 2021, 200).

Enabling learners to develop the language to express their mathematical ideas must therefore be part of the classroom that cares for mathematical learning (Lee, 2006). Listening skills are also needed by both parties if the learning is to be a shared endeavour, but importantly what is needed are tasks that provide worthwhile mathematical learning opportunities and classrooms set up to exploit those opportunities.

The social brain

Talking about a caring relationship in the classroom in this way brings me to another important aspect of the teaching for mathematical resilience relationship, that is it acknowledges the social brain (Lieberman, 2015). Studies have found that mathematics is thought of as an isolated endeavour (see for example Nardi and Steward, 2003 and Lee and Morgan, 2024) to the extent they may see working with others as ‘cheating’. Baumeister and Leary (1995), amongst others, have shown that humans have a great need to belong and will react badly to the feelings of exclusion many experience when in a mathematics learning environment. The craving to belong is at its strongest during the teenage years, just when the isolationist pedagogies seem to be most prevalent in schools. In earlier publications (Lee, 2006) I have suggested working in social ways in the classroom allows students to support one another as they engage in learning mathematics. Lieberman makes it clear that working together on a task engages a whole different part of the brain, one that is a vital part of being human, which he calls the social brain. Instead of gradually finding mathematics more off-putting and feeling more excluded by mathematics lessons, young people could engage their social brain in suitable mathematics learning opportunities, something that cognitive science sees as intrinsically inclusive and motivating. Engaging in collective problem solving or in peer tutoring all activate the social brain. Peer tutoring could ask a student to learn something in order to help out someone else, which Lieberman (2015) explains works with the natural tendencies of the students’ brains. Furthermore, most concepts that are learned in school are learned and then forgotten, a situation which becomes less true when those ideas are learned in order to

contribute to a social situation. “when we encode information socially, the social brain manages the encoding and leads to better retention of the information than the traditional memory system” (Lieberman, 2015: 288).

Caring schools

Caring compassionate relationships are being seen as the answer to a recent crisis in the number of children who are excluded from school (Wheale, 2024). It seems to me that this is especially true in mathematics lessons. Teachers who continue to teach in ways that generate mathematics anxiety, for example, imprudently using competitions, demanding that students ‘memorise this’ when they are seeking understanding and isolating students ‘because otherwise they will not concentrate’, are causing damage to students’ relationship with school as a whole not just with mathematics. Teachers who work to develop mathematical resilience, on the other hand support and include all learners and increase their motivation, which may help across other subjects.

Can all teachers create appropriate relationships?

One question I am struggling with is ‘can all teachers create the ethos in a mathematics classroom that develops mathematical resilience?’ In a system that has for so long continued to generate mathematics anxiety in its learners, it is likely that most teachers of mathematics have some lingering anxieties about mathematics. Quantitative studies have established that there is a strong relationship between teachers’ negative attitudes towards mathematics and their students’ mathematics achievement (Mensah, Okyere, & Kuranchi, 2013). It is also established that teachers who have mathematics anxiety may transfer this anxiety onto their students (Bekdemir, 2010). Real or perceived deficiencies in mathematics knowledge or knowledge for teaching mathematics will affect how a teacher presents the subject (Hadley & Dorward 2011). Any lack of self-efficacy (Bandura 1995) will affect how the teacher plans lessons, the tasks they are prepared to use and the way that they will be able to enter into a shared focus on learning mathematics. The learning relationship will be compromised and will not work to the benefit of the students.

Where teachers themselves have anxiety, they will have a negative attitude towards mathematics, mathematics anxiety is negatively correlated with self-efficacy (Hoffman, 2010) leading to teachers who do not consider they can teach well. Having had negative experiences when learning mathematics themselves, may have led to a lack of content knowledge and a lack of motivation to remedy the situation. Many of those who teach mathematics may be in this situation, probably especially at primary level. When in a class led by a mathematically resilient teacher young children may be invited to explore ideas, play with numbers, challenge one another to find a hard one or an easy one; they may be asked what is the same and what is different here. Resources will be used creatively to stimulate discussion and suggest variations on the ideas being learned together. They will work socially using mathematical language to explain their ideas and will listen to and learn from and with one another. When the same class is led by a mathematically anxious teacher, they will do exactly what the resources tell them to do, the teacher may spend a long while telling the class exactly what to do, questions are unlikely to be invited, listened to, or answered carefully. The teaching relationship will be severely compromised by the teachers own anxieties (Jain & Dowson, 2009), affecting the students’ attitudes towards mathematics, their likelihood of success and setting up a cyclical structure.

Mathematics anxiety can be treated and from what is already known about the prevalence of mathematics anxiety in those teaching mathematics, offering treatment opportunities as part of every teacher training course seems a sensible first step to improve the learning of mathematics in any country.

What do I know and what needs to be found out?

I have set out some important ideas that I am already aware of in my quest to offer mathematical resilience to all learners in educational establishments. But I still have many questions.

I know that there has to be a sense of equity within the classroom. Each actor has their own role and responsibility. It is the teacher's role to teach, to set out the ground rules in the classroom and to ensure safety. It is their job to plan and promote learning opportunities that allow mathematics to be explored and learned. It is the learner's role to learn, to take those opportunities and make the most of them, with the teacher's support and the support of those around them. There must be mutual respect, both teacher and all learners must offer each other unconditional respect for each other's values and points of view. My question is how do teachers establish this sense of reciprocal responsibility and equity? What factors allow this to happen?

I know that a classroom where mathematical resilience is developed must be a dialogic classroom. Everyone must have a voice, and everyone must be listened to. I know that attention must be given to developing students' abilities to take their rightful place within the social world of the classroom by helping them use mathematical discourse for themselves and developing their active listening skills. My question here is how can the social brain be activated in the classroom, active listening established and the reluctant given a voice?

I know that mathematics must be taught with care, for understanding not just exam success. I know that often both the teacher's and the learner's relationship with mathematics must change, anxiety on both parts can interfere with offering the intertwined care for mathematics and for the student that is needed. Only when anxiety is treated will all players in the classroom be free to explore mathematics, to reason and think in mathematical ways and, through a mutual focus on what is to be learned, understand, not memorise, mathematical concepts.

I know the offering and receiving of support has an important place in the mathematically resilient learning environment. I know that helping others explore a concept deepens understanding and it is depth of understanding that is needed not 'coverage'. It is also a way to use the social brain, the parts of the brain that promotes the human natural inclination to work together and which teenagers and younger learners are exploring and learning to use. Are there wider ways to use the social brain to learn mathematics that have not yet been fully explored?

I also know that it not straightforward to set up mathematically rich learning opportunities day in day out in which learners can use to explore the full gamut of mathematical ideas. Teachers cannot be expected to produce challenging, social mathematical tasks and activities quickly and easily every lesson. What do teachers need and how can that be provided?

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