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Article Title Stories of mathematical resilience: how some adult learners overcame affective barriers

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Abstract Some non-traditional adult learners in higher education lack mathematics qualifications, have had negative experiences of mathematics in the past, feel anxious about mathematics, lack confidence, or protect themselves by avoiding the subject. As part of a widening participation initiative, a lifelong learning centre at a large university in England developed a programme of free mathematics lessons for these learners. This paper discusses the findings from a small-scale narrative study which analysed the mathematical stories of four of these learners. The research found that, although previous feelings about mathematics lingered, participants overcame their emotional barriers to learning mathematics with sensitive support from others, specific teaching and learning strategies, and by increasing their mathematical resilience. They were able to move away from feeling frightened of mathematics, to persevere and feel more comfortable with it. The notion of perezhivanie (Vygotsky, 1994) was used to conceptualise the barriers created by past, strong emotional experiences and developing ability to manage the associated feelings.

Key words Mathematics; anxiety; resilience; adult learners; barriers

Introduction

Mathematical anxiety and avoidance are prevalent (Johnston-Wilder et al., 2015) in an economic climate in which science, technology, engineering and mathematics (STEM) are highly desirable subjects. The notion of mathematical resilience (Johnston-Wilder and Lee, 2010) was developed to encourage more mathematical engagement and reduce hidden suffering. Different approaches and models were developed to help learners 'acquire a reflective and thoughtful stance towards mathematics' (Johnston-Wilder and Lee, 2010: 218).

Background

Widening participation is a strategic priority at the Centre for Lifelong Learning at the University of Warwick, England. The centre welcomes adult learners from non-traditional educational backgrounds many of whom have other commitments including full-time work and caring responsibilities. The focus of this project was inclusion of such learners in order to open up opportunities for them to achieve more, enter particular professions and aspire higher in their careers. Free General Certificate of Secondary Education (GCSE) English and mathematics programmes were developed in 2017-18. This research focuses on the mathematics component of the project.

The mathematics tutor appointed had extensive experience, was aware of the prevalence of mathematics anxiety, and applied new andragogic approaches to address this. The notion of andragogy is applied throughout since the focus of the research is on adult learners and their 'complex networks of histories, demands and influences' (Mason, 2018: 9).

Although twenty eight students enrolled on the mathematics course only 43% of these (twelve students) completed the course and sat the examinations. A number of reasons were given for leaving the course, including difficulty combining the demands of studying for GSCEs and degree with other commitments, and lack of confidence. Interestingly, mathematics anxiety was not included. Four learners who remained to the end of the course participated in this research.

The aims of the research were to:

- Identify affective barriers to learning mathematics;
- Develop strategies to facilitate teaching and learning mathematics;
- Establish accessible pathways to study mathematics.

Methodology

Three researchers studied the stories of four, self-selecting, participants out of the twelve on the course about their experiences of learning mathematics. One of the researchers attended the mathematics sessions to inform the group about the research and recruit participants. Written information was also handed out to give participants time to consider their involvement in the research. A fourth, more experienced researcher acted as mentor to the team. A narrative approach was chosen as the best way to access people's experiences on the topic. As Lewis (2011: 505) proposed, 'it is through the story that we come to know, through the story of the other'. According to Richardson (1990: 65), stories are 'the way humans understand their lives'. There was no expectation that the

researchers would arrive at conclusive answers (de Carteret, 2008) or that there could be generalisability from this small-scale study. Instead, they sought insights about people's diverse experiences to inform future practice.

Semi-structured interviews were conducted to allow the participants the opportunity to elaborate on their experiences in depth. (The interview schedule is available in the appendix.) A comfortable atmosphere was established and close attention to the participants maintained throughout the interviews. Each researcher transcribed their own interview (or interviews) as part of the interpretive process. This was in order to deepen their familiarity with the data. Each raw transcript was of around five thousand words in length.

The researchers shared their thinking with each other, virtually and face to face, throughout the analysis phase. In this way, they engaged in a sort of counterpoint activity (Deleuze and Guattari, 1988), going backwards and forwards, building up their overall understanding of the data. A thematic analysis (Braun and Clarke, 2006) was undertaken to identify patterns in the data. In addition, points of particular interest or significance were identified in the transcripts (Smith and Osborn, 2009). Transcripts were transferred onto a three-column template with the headings 'Interesting/significant' and 'Themes' on either side of the transcript. These recurring themes and significant points were organised and re-organised under different headings with a number of sub-headings, maintaining a focus on individual stories. Through the counterpoint, interpretive process the data was finally organised under the following main headings:

- Resilience
- Self-efficacy
- Other people to help build resilience
- Positive strategies for teaching and learning
- Learners own choices, strategies and motivations
- Perezhivanie
- Affective barriers
- Fixed mind-set
- Poor teaching
- Systems as barriers to learning

This was a sensitive topic in which participants were likely to remember vivid early experiences of learning mathematics and how they were helped, or not, by teachers and families. Consequently, discussions focused on maintaining an ethical approach built on shared values of integrity and trust. Various online applications were considered for safety and reliability. Recordings were quickly saved on secure, dedicated files

and deleted from recording devices. This was to ensure that there was no opportunity for stories to be lost or mis-used.

Theoretical framework

Barriers to learning mathematics

Barriers to learning mathematics can be grouped into three main domains: cognitive, social and affective (Immordino-Yang, 2011). Here we briefly discuss each of these.

One example of a cognitive barrier that has affective consequences is when learners are not offered sufficient help or support in the zone of proximal development (Vygotsky, 1987) between what they know already and what they are expected to learn. This has been described as a learning disparity (Cobb et al., 2011) and can be described using the metaphor of a ladder with missing rungs; a 'ladder of communication' (Johnston-Wilder et al., 2018). Mathematics may be presented symbolically, rather than using iconic or enactive representations which increase the accessibility of concepts (Bruner, 1966), or instrumentally (Skemp, 1976), giving the learners rules and routines rather than helping them make connections and learn relationally. The use of domain specific technical language, used without adequate scaffolding (Pimm, 1987; Smit, 2013), can also become a barrier to learning mathematics.

In England, negative attitudes towards mathematics are a socially acceptable norm (National Numeracy, n.d.). The perspective that people either have a mathematics brain or not (fixed mindset, Dweck, 2015) is well documented (Leslie et al., 2015; Boaler, 2013). This pervasive negative attitude is reinforced vicariously by stories told by others in the community (Ward-Penny, 2011).

Those who do not understand or engage with mathematics are often identified as stupid (Johnston-Wilder et al., 2015). Some researchers (Boaler, 2005; Wilkinson and Penney, 2014) suggest that non-engagement or avoidance (Ashcraft, 2002) of mathematics is a way of self-safeguarding (Johnston-Wilder and Marshall, 2017). Other researchers describe learners who appear helpless, or encourage others to complete the work for them as exhibiting learned helplessness (Seligman, 1972).

For some learners the mathematics experience can be very negative (Kyriacou and Goulding, 2006). For others, the barrier is a TIRED approach (tedious, isolated, rote, elitist, depersonalised; Nardi & Steward 2003) with a focus on the mathematics curriculum, when an ALIVE approach (accessible, linked, inclusive, valuable, engaging; Johnston-Wilder et al., 2017) with its focus on the learners, would be more beneficial.

According to Lee and Johnston-Wilder (2017: 52), 'affective issues encompass students' emotions, attitudes, beliefs, motivation, perseverance and interest, as well as anxiety, avoidance and helplessness'. In particular, research indicates that anxiety and fear can cause learners to have restricted cognition (Ashcraft and Moore, 2009**;** Rodarte-Luna and Sherry, 2008**)**. When associated with mathematics, these barriers have long been recognised as prevalent (Buxton, 1981; Tobias, 1978). Siegel (2010) explains that humans are unable to reason when experiencing anxiety or fear since the physiological reaction in the brain creates the physical fight, flight or freeze response in the body, metaphorically 'flipping their lid'.

The preceding paragraphs highlight the potential of a learner completing their compulsory schooling with a negative approach to learning mathematics. An individual's interactions with mathematics are influenced by previous experiences and personal psychological disposition. This could be described as their perezhivanie (Vygotsky, 1994). Vygotsky describes perezhivanie metaphorically; significant factors from the environment are 'refracted through the prism of the child's emotional experience' (Smagorinsky, 2011: 336). Smagorinsky emphasises that, since every individual has unique personal experiences, interpreting them in a unique way, each learner will *engage* with mathematics in a different, unique way. These influences can sometimes trigger a powerful emotional reaction which then limits new mathematical learning (Lee et al, 2018)

Strategies for teaching and learning mathematics

Adult learners often have complex lives (Mason, 2018) and face particular challenges and barriers (Mark, 2018). They may, for example, struggle with time management or lack of confidence (Pearce, 2017). Their learning journeys may be 'fraught and stressful' (Pearce, 2017: 70) as they navigate their different roles as students, carers and employees. Work at strategic level is needed in order for them to feel they belong in the academy (Mark, 2018). The aim of this project was to provide effective teaching and learning opportunities for these adult learners, to increase their self-confidence, enhance their wellbeing and widen their opportunities, in the knowledge that adult learners can be helped to overcome their past fears in mathematics (Johnston-Wilder et al., 2018).

In cases where adult learners have 'fixed' mindsets (Dweck, 2006), or believe they cannot succeed as mathematicians, the mathematics teacher plays a complex, multi-layered role. Not only must these teachers make their teaching accessible, relevant, engaging and effective, they must also be highly sensitive, intuitive and flexible. Successful teachers possess knowledge, skill and heart, attending closely to their learners' sensibilities and feelings. They are highly respectful towards their adult learners, acknowledging the wide expertise gained from living in the world, and

multiple pressures on their time. They know how to build resilience so that their learners begin to adjust to adversity (Johnston-Wilder and Lee, 2010b) and overcome barriers, recruiting support when needed.

A 'growth' mindset (Dweck, 2006), we argue, can take place any stage in people's lives. Learners with a growth mindset focus on possible learning rather than achievements and see mistakes as learning opportunities. They are mathematically resilient as they are able to persevere through challenging learning experiences. Emotional support and subject-specific input conveyed via sensitive, successful andragogy can therefore transform adult learners into resilient, 'I can do' learners of mathematics.

This paper adopts an optimistic perspective. People can overcome anxiety about mathematics and succeed. As proposed by Johnston-Wilder et al. (2010), it is possible to help adults transform from a position of 'can't do' mathematical avoidance, or mathematical anxiety, to one of 'can do' mathematical resilience. This research draws on the stories of four adult learners who became confident, 'can do' learners of mathematics even though they were once anxious about the subject.

Establish pathways for learning mathematics

This transformation involves more than successful strategies for teaching and learning. Creating an effective pathway for anyone to learn mathematics depends on their current capabilities, and their perezhivanie, as well as their educational context. Any pathway will only be effective if the learner has the mathematical resilience to tread it. The commonly accepted definition of resilience has two elements. One concerns the stressor, or circumstance, that pushes the individual beyond their current capability. This can be experienced as a traumatic event (Schwarzer and Warner, 2013) or environmental adversity (Masten, 2001). The second is the individual's ability to maintain emotional equilibrium (Keye and Pidgeon, 2013) or their 'successful adaptation' (Garmezy and Masten, 1991: 459) to this stressor. Resilience therefore requires the occurrence of a specific, challenging experience, or on-going hurdles. It is a complex construct which correlates with other constructs such as self-efficacy (Schwarzer and Warner, 2013). Self-efficacy can be defined as an individual's belief in their capacity to succeed in a specific task (Schunk and Pajares, 2002). It is both 'an affirmation of capacity and the strength of that belief' (Bandura, 1997: 382). A resilient learner will, through self-efficacy, have a supportive belief in their ability to learn a new skill.

The construct of mathematical resilience (Johnston-Wilder and Lee, 2010) builds on the definition of resilience in a more general context and applies it to the specific challenges encountered when learning mathematics.

Johnston-Wilder and Lee identify four aspects to mathematical resilience. A resilient mathematical learner will have a growth mindset (Dweck, 2006), find personal value in mathematical achievement, be willing to engage and struggle with learning, and be able to effectively recruit support.

The concept of growth mindset has been discussed above. A realisation of the importance of learning mathematics is a key aspect of a resilient approach. For some learners, this appreciation of the value of learning mathematics develops after formal schooling, when they discover their professional or personal ambitions require a mathematical qualification (Ward-Penny, 2013). This goal may be enough motivation, but, to keep learning, an appreciation of the purpose of the particular topics in the curriculum, relevance to everyday life and usefulness of the topics is beneficial (Lee and Johnston-Wilder, 2017).

A truly resilient learner of mathematics will appreciate that time and effort spent in struggling through hard concepts is ultimately rewarding (Mason et al., 2010). They will also know they can ask for help, and useful help is available. The experience of failing to understand a concept does not indicate a lack of ability, rather an insurmountable gap between the communication of the learning and the learner. This breakdown in communication is illustrated by Johnston-Wilder et al. (2018) through the metaphor of a ladder. A resilient learner knows that although the gap may currently appear insurmountable, the expected learning is achievable if the learning is deconstructed into steps that are manageable for that learner. This is comparable to adding extra rungs into a gap in the ladder. The first person asked may not be the best source of help, so learners need to persevere in finding effective help for their particular needs. Rather than persisting with an ineffective strategy, a resilient learner will persevere by assessing the situation and trying out alternative strategies (Williams, 2014).

Findings

Barriers to learning mathematics

We asked the participants about any barriers they experienced when learning mathematics. Some participants described missing sections of learning without subsequent support. Sandra missed one lesson on percentages, and, despite being in the top set for mathematics, doing well and coping with the demands, she continued to fear the topic.

> *…feeling, mmm (.) really daunted, and actually quite, almost scared…. because the lesson had been done,…. that's always remained as if a bit of a weak spot. (S51)*

While at primary school, Helen missed many mathematics lessons.

They used to send me out to do the roses (H:104).

She said this had an impact on her later experiences.

> *When I got into secondary school I didn't really have much in the way of maths, whereas in everything else I was academically fine. (H105)*

Helen tried to communicate her need for help, but experienced failure.

> *I remember going up to [the teacher] with the books and stuff, and she just wouldn't help whatsoever, at all ...(H:120)*

Nicola described her teachers' expectations that her parents could provide the necessary support as unrealistic.

> *if you are not getting the one-to-one at school … how do they expect my parents to do the one-to-one… I'm not going to sit down with them if my teacher isn't going to tell me how to do it. (N:131)*

The participants said these experiences left them felling anxious. They talked about other such incidents, for example, public announcements from the teacher.

> *[the teacher]would shout across the classroom: 'You can do it! I know you can! (N:109)*

> *[the teacher] would make you stand in front of everyone, and then she would just be, like, "You're not good, you don't understand, you're stupid. (H:107)*

> *I always felt like I was stupid … There were times when I did something, and I knew I'd done it right, but it didn't make any difference. It didn't outweigh the other times. (N:63)*

These incidents of psychological harm contributed to the participants exhibiting learned helplessness, avoidance and negativity at the time.

Amanda avoided the mathematics by pretending to understand and moving to the back of the classroom.

> *The teacher never walked to the back to look at anybody's books. So the teacher never realised. (A:184)*

Having tried to communicate her need for help (asking for more rungs on the ladder of communication), Helen developed a strategy of avoidance.

> *[The teacher] just wouldn't help whatsoever, at all, and I went from… sitting at the front… to start sitting at the back because you didn't get asked anything. (H:120)*

She stopped asking for support.

> *I never asked her any more, it just didn't seem worth it. (H:106)*

Some mathematics lessons, then, caused psychological harm to these participants. Following repeated, negative experiences, some participants said they stopped engaging in the lessons.

Amanda possessed topic specific self-efficacy, but had a fixed mindset in relation to learning geometry.

> *I think I had the ability to be quite good at maths. (A161)*

> *shapes I just don't seem to have that sort of brain … things like Pythagoras, … I'm never going to probably get them. (A249)*

Nicola demonstrated a fixed mindset when mathematical language was not connected to anything else she knew.

> *Like 'trigonometry' and 'algebra' …. big words frightened me, and I always struggled with spelling and because I couldn't say these words in maths I just assumed I couldn't do it. (N:86)*

Participants also talked about their current feelings towards mathematics. Nicola talked of avoiding situations that involved mathematics, such as preparing tax returns.

> *I used to put it off. Just till once every two months and then it will be a pile of paperwork which used to tear my hair out. (N:157)*

Nicola recalled her feelings towards mathematics when engaging with this current GCSE course.

> *Starting maths this year it still gives me chills, (N:245)*

A range of reasons were given why these participants experienced barriers to learning mathematics. Some of their experiences, such as public humiliation, can be thought of as psychological harm with long-term consequences. However, as explored in the next section, the participants in this research identified positive strategies that supported them in their adult learning.

Strategies for teaching and learning mathematics

The participants talked about some helpful teaching strategies. Nicola said the way she was being taught as an adult, at a campus where she felt comfortable, was *'perfect'* (N:112) for her.

Helen said she appreciated the interactive, varied sessions where different activities were offered. Playing games helped her understand mathematics in an enjoyable way.

> *because she does divert it very fast, um, with like maybe a game but then a little bit of 'This is what it is' (explanatory teaching), and then maybe another game, I think that really helps, … and I've never really had that in maths classes before. (H:76)*

This active and well-paced approach was a new experience for the participants.

Sandra talked about '*very, very good, very clear*' (S:100) teaching she experienced within a marketing programme. A positive experience may not come solely from specifically mathematics teachers, and is associated with clear, good teaching in a familiar place.

The four participants talked about feeling included by the teacher in the university context, both as a consequence of the approach adopted in the classroom and the resources provided online.

> *I know what I'm doing because somebody spent the time and I have the time to sit there. I've been given the resources online, and there's more resources I know I can find online to keep going through it. (N:92)*

This scaffolded approach helped Nicola to gain independence and overcome her past fears of mathematics.

The participants also talked about understanding new concepts because of frequent opportunities for revision within sessions. Nicola said, it was all *'sinking in' (N:142).* For Helen, too, this emphasis on repetition was helpful.

> *He'll again make me do three or four [times], and then he'll continue with the same topic … for the full hour. (H:54)*

This conveys a highly personal andragogic approach whereby teachers know their learners well. Helen talked about her private mathematics tutor who made the effort to get to know her.

> *He knows without me telling him when I'm struggling. (H:16)*

This teacher shaped his approach to suit her needs, and his teaching became more finely tuned as he got to know her better. Helen talked about how he approached fractions.

> *He did it in the same way, and it didn't work, and he changed … I forget what it was, he just, he didn't change the method, he just changed …. It wasn't a pizza anymore, it was something else. (H:52)*

He wrote things down for Helen to take away and work on independently. This is an example of accessible andragogy, whereby teachers focus on particular aspects of mathematics in response to learners' needs, and then give them the tools to help them consolidate their learning independently. Such tutors empower their learners.

The participants said they appreciated how their present-day teachers made the mathematics meaningful by articulating what it could be used for. Helen's teacher provided examples to match specific concepts, for example, *…if you were in a ship or if you were a pilot. (H:60)* She said this helped her to remember things.

Although participants' former fear of mathematics remained, their new teachers helped them to overcome these feelings and access the mathematics.

> *'Cos even now, you know, that fear of saying 'Oh I don't get it! I still don't get it!' is still there. [The teacher] will then go over it with you time and time again. (N:142)*

Successful mathematics teachers make their sessions engaging, valuable and linked to meaningful contexts. The teaching is accessible to help learners feel included. Successful teachers are sensitive people who take time to listen to and get to know their learners well.

Establish pathways to learning mathematics

Our participants displayed a significant level of motivation, demonstrated by a dedicated approach to learning.

> *Quite often I can't start my homework till like, one in the morning. (H:36)*

> *I leave my house at quarter past seven in the morning, start here at eight, finish at quarter to six go straight to maths and then work till nine at maths. (A:65)*

The resilience required was present to some extent when they began their studies, but also developed throughout the course. They had a strong sense of the value of mathematics. It was, after all, what had prompted them to return to mathematical learning. Helen, Nicola and Sandra needed a qualification in mathematics for their next stage of study.

> *You know, I need that grade! I want to get onto that Master's course! (N:118)*

For Helen, the experience of working towards a common goal was very valuable.

> *[The learners] all got a common goal that they want to do it for something. And I think that that really helps… when you're at school… you're doing your GCSEs but you haven't really got an idea fully of what it is you're going to do. So I think that is very important. (H:78)*

The participants saw mathematics in a new light, describing a move away from a fixed to a growth mindset (Dweck, 2006). Learning mathematics became an enjoyable and positive experience, offering understanding and a sense of discovery that some had never felt before.

> *I'm enjoying the maths and I'm actually understanding it. I'm actually getting it. (N:4)*

> *I think I can learn new areas and new topics. (S:72)*

> *My mathematics is very limited, and I was not very confident about going to any of the classes [but] gradually… I just started to feel better about things (H:14)*

Amanda described her move from fixed to growth mindset in detail. Before starting the course she expected that she would be *'the idiot sitting in the corner' (A:225).* However, she was shocked by her ability to learn mathematics.

> *I shocked myself, I didn't, I did not expect to be that way. (A:225)*

Amanda could see the effect that this experience had on her.

> *And I think it's, you know, changed a lot about me. (A:229)*

The four participants were willing to accept that they would have to struggle as part of the learning process, and this would take time and effort. They became able to manage negative feelings, including the anxiety surrounding making mistakes, and to understand it is acceptable to get things wrong.

> *There's more going in, sometimes not immediately, sometimes I sit in the lesson with him and I feel that I'm not getting it, and two days later, it just is there. (H:14)*

> *…struggling with a certain element and then suddenly you've spent enough time and you just start to think aarh that's clicking now and then you can really enjoy it (A:34)*

> *It's ok, it's ok to get things wrong. (A:81)*

The participants were able to recruit additional support from their families.

> *A few weeks ago I turned up at her [sister in law's] house at half past twelve at night because I just couldn't get my head around a problem. (H:90)*

They learned to support and trust their fellow learners.

> *We all help each other if we are all working on the same thing. (N:144)*

Other people played an important part in these participants' stories of mathematical resilience.

Discussion

Barriers to learning mathematics

There is an historic reluctance or inability on the part of teachers of mathematics to take the affective domain into account (Skemp, 1976; Lee and Johnston-Wilder, 2017). Our adult participants identified explicit barriers to their learning, namely: historic lack of support, fixed mindset, lack of connections, fear and avoidance of mathematics. They were often isolated learners of mathematics and developed poor strategies for coping in lessons. These barriers are similar to barriers identified by learners who wanted to leave mathematics behind in Nardi and Steward's (2003) study.

The participants had specific gaps in their mathematical knowledge and understanding. Sometimes they had been explicitly excluded from mathematics lessons. These types of gaps can lead individuals to believe that they are not able to succeed and therefore they avoid mathematics. Amanda believed she could not understand geometry, and Nicola thought she could not understand anything because she could not say or spell some of the mathematical words. These participants formed a belief, a fixed mindset (Dweck, 2006), that they could not do mathematics. This type of belief creates a barrier to motivation (Pearce, 2017).

Sometimes support is offered but, as with Nicola, it is not necessarily effective support. Nicola's teacher tried to encourage her by calling across the classroom. This tactic failed because Nicola felt she could not do what was being asked of her and, as a consequence, felt publically humiliated. Nicola's self-esteem was reduced and her subsequent reaction was to protect herself by not engaging with the topic. Teachers have a responsibility to identify appropriate support for learners, but the learners should also feel able to recruit support in a safe, trusting environment (Johnston-Wilder et al., 2015).

If individuals do not think they can succeed, they will not attempt to engage with the activity, or will adopt a strategy of learned helplessness (Seligman, 1972). This may leave them more vulnerable to further harm because they have not learned to reduce their stress when they engage with mathematics (Schwarzer and Warner, 2013).

Any experience like the ones described by our participants could be perceived as a threat resulting in a physical response related to fight, flight or freeze (Siegel, 2010). Our participants developed a way of self-safeguarding when feeling threatened. Such coping strategies work at the time, but need to be unlearned when they stop a learner accessing available help in the future. When individuals experience stress, anxiety, panic or fear with mathematics, or lack 'the protections afforded by basic resources [and] the opportunities and experiences that nurture the development of adaptive systems' (Masten, 2001: 235), they need support to develop strategies for managing emotions. In such cases, learners need to develop mathematical resilience.

Strategies for teaching and learning mathematics

We found that multiple factors contributed to helping these adult learners build their mathematical resilience. Our participants spoke positively about their new experiences of learning mathematics. Sessions were engaging, valuable and linked to meaningful contexts. Their teachers made the content accessible, and this helped them to feel included. Over and above these strategies, the participants said it was important that their teachers knew them well and adapted their teaching to suit individual needs. We propose that there is value in teachers getting to know the conditions or stimuli that evoke strong feelings in their adult learners, that is, to be aware of individual perezhivanie.

For the participants in this study, other people too were important in helping them overcome their mathematical anxiety and become resilient learners. The participants were able to recruit appropriate support (Johnston-Wilder and Lee, 2010; Johnston Wilder et al., 2015). Their sources of success, then, were multi-situated, and emerged from their wider ecologies (Bronfenbrenner, 1979). For example, the participants talked about their families. Nicola talked about the practical support she received from her husband to help her spend time on her mathematics. Amanda suggested that her husband's love for her spurred her on, changing her *'whole outlook'* (A:223). Over and above what teachers can do, then, loving support may contribute to resilience.

It is difficult to unlearn habits, such as mathematical avoidance, since these are triggered by a deep-rooted fear learned through exposure to the world. Something as complex as fear of mathematics, we propose, is

unlikely to be dispelled by means of andragogic strategies alone. As discussed above, such andragogic strategies could include making the teaching engaging or providing online materials to support independence. Factors such as learning about the fight, flight or freeze response (Siegel, 2010), support from friends, solidarity amongst peers, or love in families can provide crucial support for recovery from mathematical anxiety, together with the skill and confidence to self-safeguard in situations where anxiety is triggered.

Establish effective pathways for learning mathematics

These findings support the construct of mathematical resilience as described by Johnston-Wilder and Lee (2010), and demonstrate development of mathematical resilience in all four areas: growth; recruiting support; appreciation of struggle; and valuing mathematics. Our participants overcame sometimes significant affective barriers to learning by developing their mathematical resilience. They stayed the course and achieved their goals, although, in this respect, they were in the minority in their cohort. The approaches and strategies that were accessible and achievable for them may need to be made more explicit and attainable for the majority of adult learners of mathematics to succeed.

Adult learners of mathematics who have experienced harm can be defensive. Sharing the learning power of a growth mindset may counteract feelings of inadequacy which trigger a defensive approach. Clarifying expectations of the need to recruit support within the learning community may encourage hesitant learners to explore possible sources of support. The ladder model (Johnston-Wilder et al., 2018) has been found to be a useful learning tool to empower learners either to ask for more rungs in the ladder or to find them for themselves.

Our participants came to realise that struggle is an integral part of learning mathematics, and not an indication of inability to learn. They learned to cope with this struggle, self-regulate and manage their emotions, persevere through uncomfortable though bearable emotions and know when to withdraw from the learning situation and protect themselves when their emotions interfere with their learning (see, for example, Johnston-Wilder et al., 2018).

As mature adults returning to mathematical learning through choice, our participants realised value and purpose in learning mathematics. However, this may not be the case for all. Ensuring that the value of each mathematical topic is made explicit throughout the teaching may increase motivation and ultimately resilience for otherwise excluded learners. Mathematical teaching that is underpinned by explanation and relational

understanding (Skemp, 1976) and illustrated with practical application can also achieve this goal.

Conclusion

There were some limitations to this research. We did not elicit stories from learners who left the GCSE programme at university. Such stories might have revealed what additional support was needed by these learners to help them acquire mathematical resilience. A more diverse group of participants might have provided wider perspectives on the topic. However, we sought individual perspectives, and these individual stories provided rich insights into people's mathematical resilience.

Development of mathematical resilience is possible, we discovered, when a number of disparate factors combine to change firmly ingrained habits such as mathematical avoidance. The four adult learners in this research had already shown significant general resilience in their lives. They had committed to go to University after a long gap in study and despite earlier struggles with education, and were motivated to combine study with other responsibilities. Thus these learners had already revealed a disposition to change. They showed further signs of resilience and self-belief when they joined the mathematics GCSE course at university. They proceeded to find value in their mathematical achievement, demonstrated willingness to struggle, and when needed, effectively recruited support.

Over and above these personal dispositions, we found that skilled teaching was a crucial ingredient. An ALIVE teaching approach (Johnston-Wilder et al., 2017) supported the process of recovery, helping the participants overcome their former fears. We also discovered that wider factors were at play. When anyone returns to something they fear, such as gaining a qualification in mathematics, their perezhivanie (Vygotsky, 1994) might play a part whereby their past, negative experiences of learning mathematics are re-ignited in different ways. The participants said that other people helped them as they navigated their new learning journeys, including teachers, peers, neighbours, children, partners and friends. Amanda, for example, said that her husband encouraged her to overlook any obstacles and pursue her desire to progress in her studies.

> *When I graduate I'll be 49 … [My husband] looked at me … and said Amanda, in five years' time you'll be 49. Anyway, why not be 49 with a degree? And that was it, I know (giggles). Why not be 49 with a degree?* (A:221)

She said this changed her *'whole outlook'* (A:223). Over and above what teachers can do, then, it is possible that such things as love and friendship have the power to change deep-seated emotions and habits.

As Masten (2001: 235) proposed, resilience may be acquired 'from the everyday magic of ordinary, normative human resources in the minds, brains, and bodies of [people], in their families and relationships, and in their communities'. From this perspective, the social and emotional aspects of learning are as important as the cognitive. People's feelings about mathematics in relation to their past experiences and current levels of support from others, as well as their own beliefs and motivation play an important part. This is more than any mathematics teacher can address alone. In this small scale research we found that mathematical resilience may be achieved when a combination of factors are at play, including: learners' own self-belief; the presence of sensitive, attuned and highly skilled mathematics teachers; the support of others; and any other factors in people's complex life ecologies. We propose that departments establish appropriate opportunities for their adult learners to gain mathematics qualifications and thereby access wider professional pathways.

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Appendix

My previous experiences of mathematics

You are invited to share your personal maths story todate, that is, your previous experiences with maths, good and bad, and your thoughts about those experiences.

1. First, could you tell me about one of your best experiences of maths.

   What was happening? What were you feeling? What made it a [good] experience? What were others doing that contributed to this being a [good] experience for you? What did you contribute to making it a [good] experience?

   (If needed, suggest that the participant consider the best GAIN experience.)

2. Second, could you tell me about one of your worst experiences of maths.

   What was happening? What were you feeling? What made it a [bad] experience? What were others doing that contributed to this being a [bad] experience for you? What did you contribute to making it a [bad] experience?

   (If needed, suggest that the participant consider the worst GAIN experience.)

3. Third, could you tell me about an experience where you struggled with maths alone?

   What was happening? What were you feeling? What did you try? What helped or didn't help?

4. Fourth, could you tell me about an experience where you asked for help with maths?

   What was happening? What were you feeling? Who did you ask for help? What kind of support were you hoping for? What was helpful/unhelpful about the help you received?

5. If you had any suggestions that would help you learn maths better, what would they be?
   What might the learners do differently? Teacher? Different resources? Different tasks?

6. What do you most value about learning maths, for example on the GAIN project?

   Possibly refer to answer to Q1.

b) What do you least value about learning maths, for example on the GAIN project?

Possibly refer to answer to Q2.

7. What have you learned about yourself as a learner of maths?

8. What have you valued most about your fellow learners in the GAIN maths class?

b) What have you valued least about your fellow learners in the GAIN maths class?

9. What do you value most about others who have supported your maths development? Teachers? Parents? Friends?
b) What do you value least about others who have supported your maths development? Teachers? Parents? Friends?

10. Might you undertake maths A level in the future?
Under what circumstances? What would it take? What support might you need?

Ending: Is there anything else you might wish to say?

Thank you for your time.