Developing Coaches for Mathematical Resilience

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Authors’ note

The project is funded by a grant from the University of Warwick Science Park: http://www2.warwick.ac.uk/services/academicoffice/ourservices/saro/wp/heat/stemprogramme/

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## Abstract

The construct ‘Mathematical Resilience’ (Johnston-Wilder & Lee, 2010) describes a positive stance towards mathematics that enables learners to overcome the barriers and setbacks that can be part of learning mathematics. A resilient stance towards mathematics can be engineered by a strategic and explicit focus on the culture of learning mathematics within both formal and informal learning environments. One part of that cultural engineering is the notion of coaches to support emergent resilience. Coaches work beside learners, helping to manage emotions, maintain feelings of safety and managed risks when facing difficulties in mathematics. Coaches help develop a culture of ‘can do’ when learning mathematics which counters helplessness and mathematics anxiety. Coaches are not required to know the mathematics, but rather to know that active learning approaches might yield an understanding of the mathematical ideas and thus lead to an answer or to progress in learning.

This paper discusses the outcomes of a pilot course designed to develop ‘coaches for mathematical resilience’. The data confirms our hypothesis; in order to become effective at coaching in resilience towards mathematics, an individual must first develop personal mathematical resilience in a safe and collaborative environment. An environment that exposes the participants to mathematical ideas in a supportive community enables them to consider and manage their reactions to mathematical ideas. That in turn enables participants to reflect on how to help someone else find the resources to overcome barriers to learning mathematics. Such an environment is effective in enabling participants to become mathematical resilience coaches who can impact positively on learners of mathematics, without teaching or taking responsibility for the mathematics.

Keywords: mathematics anxiety, learned helplessness, mathematical resilience, coaching.

## Developing Coaches for Mathematical Resilience

## Introduction

Mathematical resilience (MR) is a positive construct derived by applying lessons from the wide literature around resilience to the learning of mathematics. It is a positive stance towards mathematics, wherein the possessor of MR understands that learning mathematics may involve struggle, but knows that with hard work, curiosity and persistence, learning will grow and with it will come the feelings of satisfaction and pleasure from a challenge met and overcome (Lee & Johnston-Wilder 2013).

A positive stance towards mathematics becomes more important as the place of mathematics is understood more in terms of building a successful career (Norris, 2012) and in terms of the need in society for those who are willing and able to use mathematics (Roberts 2002). Teachers are beginning to work with this construct, working to develop MR with their pupils, challenging them and allowing them to struggle and feel the fulfilment of meeting those challenges (e,g, Chisholm 2014). However, rather than being mathematically resilient, many people who are articulate individuals and ‘good’ learners in every other sphere of their lives, are anxious about or avoid mathematics to a greater or lesser extent (see for example, Ashcraft 2002, Brown et al. 2007, Newman, 2004, Hoffman 2010). They also develop “learned helplessness”, a feeling that whatever ideas they may have or actions they take will not result in them being successful in mathematics; the teachers’ way is the only way. This has resulted in ‘the mathematics problem’ in a Western society that requires more mathematicians, scientists and engineers, and people willing to handle quantitative and graphical information but whose education system is unable to provide them at least in part due to mathematical anxiety (see for example OECD, 2010).

This paper is a report of a short pilot course developed to enable the development of coaches for mathematical resilience, aimed at anyone whose role it is to support someone else as they learn more mathematics. Many learners do not have access to well-qualified mathematics teachers either because of the shortage of such teachers in schools or because they are learners of mathematics now beyond the formal reach of school. In this case “coach” was seen as someone who supports another in accomplishing a learning task. The attendees were not “teachers of mathematics” themselves but rather supporters in the task of learning sufficient mathematics to achieve the goals that the people they were supporting had set themselves. In what follows, we build a case for the training of adults to act as mathematical resilience coaches is built. These adults, in acting as coaches, take no responsibility for the mathematics, but rather focus on the well-being of the learner to ensure that mathematical helplessness and anxiety are addressed explicitly and safely, and that mathematical resilience is developed, thus enabling better progress in mathematics learning.

The pilot of a course to train such adults as ‘coaches for mathematical resilience’ is described and discussed. The pilot course ran from April to June 2013. The course recruited 11 participants who regularly work with apprentices in work-based environments and who are required to learn and use mathematics as part of their on-going training. Some already had some coaching expertise. They all became part of the course due to recognition of their own lack of knowledge about how to overcome deep-seated antipathy to mathematics in those who they work with and, in most cases, within themselves.

For over 40 years, mathematics anxiety has been recognised as a widespread condition for over 40 years. It is described as “feelings of tension and anxiety that interfere with the manipulation of mathematical problems in a wide variety of ordinary life and academic situations” (Richardson and Suinn, 1972, p.551). That anxiety has a negative influence on working memory is well established (see for example, Ashcraft et al, 1998). According to Skemp (1971), inhibiting reflective activity. Studies from many countries have shown that performance in mathematics is negatively correlated to mathematics anxiety (see for example: Betz, 1978; Hembree, 1990; Ma, 1999; Dowker, 2005; Ashcraft and Krause, 2007; Brunyé et al 2013). Thus mathematics anxiety causes under-achievement in mathematics. What is not clear is how much under-achievement.

In the UK, students need to gain a grade C in mathematics in GCSE examinations taken typically at age 16 in order to enter university and many professions. In 2012 two-thirds of students who achieved a D grade in their mathematics at GCSE at secondary school in 2012 (54,000 young people) did not enter the exam in post-16 education (SFR13/2013). It is our hypothesis that, had these young people had mathematical resilience (Johnston-Wilder and Lee 2010), they would have seen a grade D as one step away from a grade C and would have continued to work towards a grade C, and take advantage of a grade that provides a great deal of the cultural capital that would bring in England.

However, rather than being mathematically resilient, many people who are articulate individuals and ‘good’ learners in every other sphere of their lives, are anxious about or avoid mathematics to a greater or lesser extent (see for example, Ashcraft 2002, Newman, 2004, Hoffman 2010). This has resulted in ‘the mathematics problem’ in a Western society that requires more mathematicians, scientists and engineers, and people willing to handle quantitative and graphical information but whose education system is unable to provide them at least in part due to mathematical anxiety (see for example OECD, 2010).

This paper briefly explores what is known about why learners of mathematics develop anxiety and helplessness, supplementing the research literature with some ‘brief but vivid’ qualitative data (Mason 2002). ‘Mathematical resilience’ is then explored in terms of how it describes what might be developed in learners as a solution to feelings of anxiety and helplessness. In what follows, a case is built for the training of adults to act as mathematical resilience coaches. These adults take no responsibility for the mathematics, but rather focus on the well-being of the learner to ensure that mathematical helplessness and anxiety are addressed explicitly and safely, and that mathematical resilience is developed, thus enabling better progress in mathematics learning. A pilot of a course to train such adults as ‘coaches for mathematical resilience’ is then described and discussed. The pilot course ran from April to June 2013. The course recruited 11 participants who regularly work with apprentices in work-based environments and who are required to learn and use mathematics as part of their on-going training. Some already had some coaching expertise. They all became part of the course due to recognition of their own lack of knowledge about how to overcome deep-seated antipathy to mathematics in those who they work with and, in most cases, within themselves.

## Development of mathematical helplessness, avoidance and anxiety

According to psychological research (for example Seligman, 2007), repeated exposure to unpredictable and inescapable stress can lead to learned helplessness, anxiety, inactivity, and fear. Stress experienced by a learner can be productive. “Good stress” can result from external and internal stimuli that are mild or moderately challenging but limited in duration. Stress such as this can result in a sense of mastery and accomplishment, often experienced positively, and can be exciting. However, situations involving more prolonged, repeated, or chronic stress, which may be experienced as uncontrollable or unpredictable and involve a lower sense of mastery or poor adaptability, can lead to a more negative stress response.

The ‘primitive’ brain stem is involved in physiological and emotional responses to stress, thus invoking fight, flight or freeze responses in extremis. Neurobiological evidence shows that, with increasing levels of emotional and physiological stress, prefrontal functioning decreases, cognitive control reduces and, consequently, there is increased risk of maladaptive behaviours, such as avoidance, helplessness and anxiety. (See for example, Sinha, 2008.)

Here is a description of one such negative experience with school mathematics from the journal of a young woman we shall call Heather:

“i remember sitting in my yr.6 class room, my teacher was miss jackson and we were doing maths we were working on long division, i got a red cross on some of my work when i checked on the calculator the answer was correct, (mmm) this puzzled me so when i questioned my teacher she said it was because my working out was wrong and made me feel stupid in front of my peers when i explained (translated) my methods.”

Heather, as a child, had demonstrated mathematical resilience, in that she had been willing to ‘have a go’, had reached a correct answer and asked for clarification when she was puzzled by the teacher’s marking. The teacher’s focus in this situation on ‘the right method’ seems to have undermined the child’s existing mathematical resilience, and contributed to Heather as a child experiencing loss of social esteem, loss of willingness to ask questions in the future and thus loss of innate mathematical resilience. Subsequently, Heather became a mother.

Here is part of Heather’s written account of her experience of wanting to support her daughter, but being in a position of personal mathematical helplessness and anxiety.

“throughout the years when i've worked with my daughter on maths homework its been a combination of falling out, shouting, tears, avoidance feeling stupid on both parts her putting herself down me trying to restore her confidence but both of us to tense and stressed for it to make any difference, of recent years she began laughing at me for using a calculator and not understanding, pointing out what year she is in and that i need to go back to school.”

Heather had the expectation that, as a mother, ‘she should be able to help’ as she did with other subjects; and her own self-image was of total failure in relation to mathematics and that it was ‘too late’ for her.

### Solution: development of mathematical resilience

Building on neurobiological understanding of affect as an integral part of cognition (Adolphs & Damasio, 2001), we have built a pragmatic description of ‘mathematical resilience’ (Johnston-Wilder & Lee, 2010). The construct ‘mathematical resilience’ has been explicated to describe a positive stance that can be developed by learners towards mathematics. By adopting this stance learners approach mathematical learning in ways that allow them to overcome the affective barriers and setbacks that are part of learning mathematics for many people.

However Heather’s case is now used as an illustration of how a focus on developing mathematical resilience can change the experience of the learner, with no expectations of mathematics expertise on the part of the supporter, as is illustrated here through the case of Heather.

In Heather’s case, she was offered the idea of mathematical resilience and a resource, in the form of a mathematics dictionary. She was encouraged to be aware of her own everyday use of mathematics, and to focus her attention on her role as ‘curious, supportive, listening mother’ rather than inadequate mathematics ‘expert’. Heather developed no extra mathematical knowledge, but the change for Heather and her daughter was nevertheless dramatic. Heather’s subsequent behaviour demonstrated that she had overcome her learned helplessness. She demonstrated in the mathematics arena that the cure for learned helplessness caused by stress is to use the natural stress responses in which the first stage is curiosity and excitement (Seligman, 2007). She was able to help the learner, her daughter, maintain control of the duration and intensity of the stressor (learning mathematics) and therefore enable the level of stress to remain productive. The following extract from Heather’s journal of her subsequent, resilient behaviour shows that she and her daughter now use resilient strategies to overcome barriers and maintain curiosity and excitement, with Heather controlling the stressors and supporting her daughter in developing mathematical resilience, without taking responsibility for the mathematics.

“one day after[my daughter] came home from school she curiously asked me for the text book they had been working from that day in school, she confidently flicked the page open to an angles section where there was a page full of lines in all directions, and said "we were doing this today but i don't get it " so i said well lets have a look then, with a few minutes she understood, it turned out that all that really confused her was the layout of the page as it was full of lines set up in twos connecting at one point and were heading in all sorts of directions”

Heather’s response is one of getting out the home copy of the school text, combined with supportive curiosity and listening; there was no need for her to input any mathematics. Her daughter expected Heather to be helpful and supportive, and to be there to help her learn, not to know current school mathematics. If her daughter had needed any mathematical help, she could have made contact with a mathematics expert with her mother’s support and encouragement. Thus, the home situation is no longer stressful or helpless but is one of growth promotion in manageable steps. Heather’s subsequent behaviour demonstrated that she had overcome her learned helplessness. She demonstrated in the mathematics arena that the cure for learned helplessness caused by stress is to use the natural stress responses in which the first stage is curiosity and excitement (Seligman, 2007).

Originally, from the literature and experience, Johnston-Wilder and Lee (2010) theorised mathematical resilience as having four factors:

1. belief that brain capability can be grown (Dweck 2000);
2. understanding of the personal value of mathematics (eg Ainley and Pratt 1995; Nardi and Steward 2003);
3. understanding of how to work at mathematics (Bandura 1997, Mason, 1999);
4. awareness of the support available from the wider community; peers, other adults, ICT, internet, etc.(Lave and Wenger 1991, Zaretskii 2009 )

Thinking about coaching learners so that they develop mathematical resilience has resulted in the development of the “growth zone model”. Standing on the shoulders of Vygotsky (1978, 1981), they have subsequently found it helpful to think of mathematical resilience can be thought about as what is needed to stay in the “growth zone” with feelings of safety and for as long as possible. Using the “growth zone model” has been developed to enable learners are enabled to articulate the feelings of risk and uncertainty that can accompany the learning of new mathematical ideas. It is intended to enable learners to think about and articulate how they feel in terms of moving beyond where they feel safe when learning or dealing with mathematics so that they can learn new ideas. The model can further help in expressing the idea that learners must move forward, but not so far from their safety zone that the stress becomes unbearable. The idea of the growth zone has developed from a reading of Vygotsky’s (1978) zone of proximal development (zpd). However, the growth zone is distinct from the zpd and not intended to reflect all nuances of the zpd. Importantly, it is only when a learner moves beyond their comfort zone and into their growth zone that new learning can happen.



Figure 1. The growth zone model.

The safe zone or ‘comfort zone’ or ‘green zone’ encompasses everything the learner can already do independently. Cruising in the ‘comfort zone’ can build self-confidence, provide opportunities to practise and to develop automaticity, give reassurance and allow for recovery from any stress encountered. However, staying too long in the comfort zone means that no new learning happens and boredom is a possibility. The ‘growth zone’ or ‘amber zone’ is described as that zone immediately beyond what a person is able to do reliably, without aid or support. In order to establish a “growth zone” it must be made is safe to make mistakes, go down dead-ends, experience some failure, require and receive support, get stuck, and find activities challenging and tiring. Being in the growth zone may trigger “good stress”, bringing productive levels of adrenalin, which might develop feelings of excitement or mild anxiety; drawing attention to the likelihood of such feelings and the availability of support can help a learner stay longer in that growth zone. When the learning environment is one of trust, courage, articulation, collaboration and persistence, more students will enter, and choose to stay, in their growth zone. Ideally, students will feel motivated and appropriately supported – and have opportunity – to enter their growth zone repeatedly, over extended periods of time. (see also Zaretskii, 2009) The underlying theory is one of social constructivism; that many learners do better at mathematics if they learn in groups, with conjoint agency (Markus & Kitayama, 1991).

In this model, the danger zone or ‘anxiety zone’ or ‘red zone’ is one where what is being asked of the learner is not within their reach, even with support. With increased exposure to such demands, the learner’s level of stress increases and the brain begins ‘fight, flight or freeze’ routines. There is less, or in extremis no, useful learning taking place, and learners increasingly use maladaptive coping strategies of avoidance, helplessness or even paralysis.

On the basis of this model, we propose that positive experiences of mathematics, together with a language of risk awareness and risk management which is based on the “growth zone model”, can help learners, who would otherwise avoid mathematics and fail to achieve their goals in life, to develop risk taking and risk management processes which enable them to approach mathematics with then lead to the development of mathematical resilience and thus to achieve mathematical growth. In order to maximise the potential for learning, learners need to experience protective factors of connection, competence and opportunities for participation and contribution. However, this does not all need to happen within formal mathematical learning environments.

In the work described later in the paper, we also refer to the growth zone model in Figure 1 as the RAG zone model, and to the zones as the RAG zones: RAG is an acronym for the colours of the zones: Red, Amber, Green.

## Role of coaches

It is our belief that a resilient stance towards mathematics can be engineered through a strategic and explicit focus on the culture of learning mathematics within both formal and informal learning environments. In the context of the current chronic shortage of teachers of mathematics in the United Kingdom, it seems to us that part of the solution resides in developing mathematical resilience outside direct mathematical teaching environments. One proposal for achieving this lies in developing ‘coaches for mathematical resilience’, who behave much like Heather, in everyday life.

Traditionally, a ‘coach’ in this definition will support, respect, listen, be compassionate, validate, model resiliency, and refrain from judging, thus enabling those in receipt of coaching to feel safe in taking the kinds of risks that they may need in order to grow their capability (Whitmore, 2013). We envisage coaches for mathematical resilience helping learners to recognise for themselves when they are in their mathematical growth zone, encouraging learners to value the challenges this brings and helping them to manage the emotions involved. Coaches are in a position to use a language that allows students to recognise and articulate what degree of challenge they are facing, encouraging increasing independence and agency. They can: model learning strategies; model being part of a community of practice; show that knowing how to access help and how being prepared to access help are positive ways to develop personal mathematical resilience. Any adult, ‘mathematical’ or not, can support a learner of mathematics by understanding the potential for a learner to experience the emotions described by the zones, and by encouraging explicitly the development of mathematical resilience.

The work described here is focused on developing coaches who work beside learners, helping them to think about and use resilient learning ideas when facing difficulties in mathematics. Coaches develop a culture of ‘can do’ mathematics when their learners are faced with challenging mathematical ideas. This works to counter the culture of mathematics helplessness and mathematics anxiety which is prevalent in the general population. The coaches are not required to know the answer but rather to develop the learners’ ability to recognise options and actions that might yield an understanding of the mathematical ideas involved and thus lead to an answer.

## Design of Course for Coaches

The pilot course was designed and facilitated by a mathematics education specialist from the Centre for Education Studies at The University of Warwick and a coaching specialist from The Progression Trust, and accredited by ASDAN in a collaboration based on a resonance of pedagogic approaches. The Coaching for Mathematical Resilience course combines two main features: firstly, development of coaching skills and attitudes, which reflect the principles of developing resilience in learners, and, secondly, the development of a personal ‘can do’ approach to mathematical challenges (see Fig. 2).



Figure 2. Two input elements and two output elements (Garton and Johnston-Wilder, 2013).

The Coaching for Mathematical Resilience (CfMR) course was designed in two levels: 1, Foundation Level in which learners work to develop their own Mathematical Resilience; and 2, Practitioner Level in which learners apply their resilience to working with, and coaching, learners in developing their own Mathematical Resilience. The 10-week pilot course reported here was at Level 1 and was offered to local employment-based training providers and also to the local Looked After Children team; 12 women came to take part in the pilot, mostly experienced assessors and trainers, all but one with their own mathematics anxiety or avoidance.

### The approach to developing personal mathematical resilience

From the first session developing a learning community was a focus, with emphasis on:

* developing a growth belief towards mathematics;
* understanding that mathematical learning could be developed if we started from where the individuals currently are – inclusion;
* allowing the participants opportunities to experience mathematics in a safe environment;
* identifying emotional responses to mathematical challenges;
* developing the participants’ awareness of agentic behaviour, i.e. how to take control of personal experiences.

The course was designed as ten half-day sessions in which strategies for achieving the intended coaching and mathematical outcomes were interwoven as shown in the outline of the planned sessions in Table 2.

Table 2

The planned sessions

|  |  |
| --- | --- |
| Week 1 | Creating the learning community, ground rules, fun maths, fostering curiosity, need to acknowledge positive and negative emotions |
| Week 2 | Developing awareness of what mathematics looks like in everyday life |
| Weeks 3-9: | Developing awareness and skills of coaches, using Egan (2013), in the context of challenges from the ASDAN Mathematics short course focused on Number, Money, Probability, Statistics, Mathematical Discovery, Algebra, Geometry |
| Week 10: | Reviewing portfolios and celebration: presentation of certificates, sharing images of what it means to be mathematically resilient; mathematics-related food. |

The data from the course consisted of planning documents and notes from discussions on the form that the course would take and on changes that were decided on from week to week as the course progressed. As part of each session the participants were asked to reflect on their experiences and notes were taken on what was reported in these sessions. Further critical moments were recorded by the leader that was not facilitating the particular session in the course. A major source of data were the notes that the participants kept in their own folders and made available to us to read and copy.

At the end of the pilot course participants were invited to take part in an evaluation interviews of around 30 minutes. The interviews were conducted using Appreciative Inquiry methodology (Cooperrider, Whitney, & Stavros, 2008). They focused on ‘high points’ and ‘special’ moments as these are a signal for points at which participants were engaged, inspired or motivated. By understanding better what factors contributed to these moments, it is possible to identify the underlying attitudes, actions and environment that can be built on in future to improve engagement, innovation and motivation, and make them the norm rather than the exception. Particular parts of the Appreciative Inquiry methodology elicit specific insights about participants’ wishes, intentions and values. The actual language used by the participants themselves is very important as it is the language that they use to express what they value.

All these sources of data were meticulously analysed by each of the researchers separately with the intention of uncovering the important aspects of the lived experience of the participants and what had contributed to that experience. The separate findings were then synthesised into the results reported here.

## Results

There was particular emphasis of on the idea that the mathematics that participants already know is enough to enable them become a coach. This encouraged all participants to feel included in the mathematics of the course and not to hide any insecurities that they had about areas of mathematics. The mathematical ideas explored in the sessions were those that the learners they engaged with in their day to day roles were likely to come across As an example, we showed the participants were shown how, using a triangular prism (such as a Toblerone packet), they could develop a personal conversion scale between percentages, fractions and decimals.

The idea that each participant’s mathematical understanding can grow was explicitly discussed. In all our work it was emphasised that the intention would be to be inclusive, that is to start from what participants already understand, encouraging them to use what they know and to build from there; thereby increasing the time spent in their personal mathematics growth zone.;

A learner’s sense of agency in the learning process is an important factor in building mathematical resilience. To encourage participants to feel able to take more responsibility for their learning, the participants were encouraged to use Red, Amber and Green (RAG) cards as a way of expressing their current state of their emotions in terms of the growth zone model. Through these cards the participants could acknowledge and express their emotions towards the ideas that the group were exploring, including their vulnerability. As participants began to use the RAG cards more, they expressed how they were becoming aware of taking responsibility for expressing and managing any feelings of panic and anxiety by first acknowledging those feelings and then engaging help to dissipate them.

In terms of the underpinning coaching approach, in weeks 3-9, the discussions of the coaching approach were based on the Egan model (Egan, 2013), in which learners are supported to explore a problem, consider their options and plan actions, rather than feeling rushed into action and anxiety. In parts of each session, participants took the role of ‘learner’ or of ‘coach’, in order to allow them to experience the feelings associated with each role, and come to understand from experience how the process works.

In the first session, the group established their ground rules as: honesty, trust, helping each other, respect, sharing responsibility for one another’s well-being and progress and for establishing a positive working environment.

At the start of session 2, reflections were invited. The participants said they were: interested, excited with the prospect of the challenge, liking the idea of being challenged and feeling that they “can do” mathematics with support. They said that the RAG cards gave them a way of expressing an interest while showing a lack of confidence to attempt the work.

Further on in session 2, the participants began to reveal their emotional responses to the mathematical challenges. When one saw algebra, she closed the book, two others expressed feelings of social isolation. However the majority expressed feeling included. Once some everyday activities had been identified as mathematical, the participants began to understand where mathematics could be found in other everyday situations. Even though we had emphasised to the participants that they were not teachers of mathematics, in this early stage they still seemed to carry the belief that they were responsible for teaching mathematics, for ‘demonstrating what to do’. For this reason, from session 4 onwards, a greater emphasis was laid on developing coaching skills.

Over the following weeks, it was evident from their apparently open, honest reflections and from the notes in their folders that mathematics anxiety, to the point of panic, was never far away for some participants. The participants appeared skilled in hiding their anxieties, and therefore, identifying when someone was in the red zone was not easy for the course leaders. The use of the RAG cards allowed and supported the participants and the coaches in acknowledging their emotional reaction to mathematical challenges, particularly to each other when taking on the roles of learners and coaches. The notes indicate a developing awareness of the impact of their own negative emotions and anxieties on others’ ability to function and therefore, the importance of appearing calm when in the coaching role. The RAG concept model further supported the learners to step outside their own feelings of panic and observe themselves having “a meltdown”, seeing the physical manifestation of what this meant: for example, not reading the question, getting frustrated and angry, and feeling stupid.

After being coached through a mathematics problem for a session and being given feedback, the learners reported feelings of pride, leaping forward, believing they have learned some mathematics, feeling calmed down, seeing alternative methods, and getting correct answers with support and struggle leading to increased confidence. The coaches reported that they were able to respond more appropriately, and with increased openness, to the learners for whom they had responsibility when using the RAG cards. One remarked: “Experiences of [the] course are helping [me] understand learners better.” They said that they began to understand how others might feel about mathematics, that to some learners mathematics is a foreign language, and that they needed to accept learners’ own preferred way of working and not impose methods onto the learner. When in the role of coach, developing helpful ways to support learners in developing strategies to overcome mathematical challenges, they reported becoming aware that a learner attempting a mathematical challenge will often need to be offered a meaningful context for the challenge.

In session 7, after a break for half-term, the participants shared their reflections on the previous six sessions. It was notable that during this session the participants often made comments using mathematical language and laughed about their relaxed use of mathematical terms. Some of them told us that they had talked about the course with their families, making them aware that mathematics is used by everyone every day. Others told us that they used the RAG cards, not just when discussing mathematics but at home and at work.

For some, session 7 was experienced as a turning point in their understanding of how they could support learners without knowing any more mathematics themselves. This has implications for considering alternative models for CfMR – transformation takes time. One participant commented “How liberating! The learner needs to know the maths. It’s not a weakness for the coach to find out as well, because a coach knows they shouldn’t jump in and tell. The learner keeps responsibility for the maths.”

Others described their experience of the coach thus far as: ‘calming me; making me feel comfortable; reining me in, taking me back to the task; chunking the task for me; slowing me down, focusing me on making a start; checking with me what is familiar; highlighting terms I didn’t understand; getting me coffee – encouraging me to: breathe, find out, read the question, check the task, ask questions, take a break, try a little harder, struggle for longer or shorter depending on my emotional state, learn by my mistakes, have a go’. They noted that the best experiences were when the coaches did not interrupt, listened and trusted the learner, reassured and shared enthusiasm and curiosity. They also noted how important it was to be made to feel comfortable when making mistakes, because learners “learn by mistakes; when you are learning, you need time and opportunity to try out”.

Many of those being coached experienced a wonderful feeling they described as the ‘got it!’ feeling, a feeling of significant achievement. Those doing the coaching noticed that they were becoming able to hide their own feelings of anxiety in service of supporting the learner; they used the analogy of a swan or a duck, apparently calm and gliding in the session and all the movement hidden in the paddling underwater. Based on the evidence in their folders, they all came to recognize this as an important part of the role of the coach; one participant commented there was a risk of passing on mathematical anxiety to others “so we need to be a really a good role model”.

In the final session, participants illustrated their view of what it meant to have become personally mathematically resilient. The images that resulted had three alternative foci: the RAG zone, transformation and being in possession of a life-belt. One participant focused on how it feels for her when she is in what she had come to call her amber zone. The images of transformation included: a blossoming tree; a step-wise transformation from ape to woman, head held high; transformation from puzzled, through light-bulb moment, to smiling; transformation cygnet into swan; transformation of seed to flower. Throughout the course participants referred often to how valuable it felt knowing she would not be abandoned by her peers on this course.

The participants commented at length during the appreciative enquiry interviews. These are some of the comments made by the participants about what they appreciated, they commented that they appreciated:

‘sessions are not lectures; they are a bit like therapy’

‘we have been encouraged to move into our amber zone’

starting from ‘where you are’

‘the Toblerone ruler will help many learners’

‘the [RAG] cards were useful’

The high points the participants identified were: using the growth zone model, the learning environment, specific mathematical tasks, and simply ‘all of it’. The elements that made up the special moments were a combination of: having understood; having a sense of achievement; working together; enjoyment and excitement; being in a safe learning environment; receiving positive feedback.

At the start of the course the participants related that they had felt: anxious and panicky; confused and frustrated; empathy for their own learners; excited. During the course they said that they felt: enjoyment; motivated; empowered; engaged; proud; confident. Finally, they reported feeling: comfortable; safe; supported and part of a learning community; a sense of achievement.

The contribution of other people acting as coaches to the success of these particular moments was also mentioned. When coaching others had: listened and taken a back seat; asked questions; developed confidence in others; given constructive feedback; shown respect and inclusion; calmed and reassured; made suggestions; used useful strategies; worked together; supported each other and shared.

When acting as coaches themselves they recognised that they had: contributed specific strategies, questions and skills; listened; shown respect and flexibility; been interested, enthusiastic, confident and willing to have a go; been open and honest; given constructive feedback; shown commitment; worked together, shared and contributed different things.

Participants were asked to describe times outside of the Coaching for Mathematical Resilience course when they were engaged in and excited about what was happening. Examples of the high points they identified included:

* with groups of learners, feeling confident to support and to use coaching for mathematical resilience skills in lessons;
* with individual learners, feeling confident to support and to use coaching for mathematical resilience skills;
* supporting learners preparing for mathematics tests and examinations;
* explaining the course to family members;
* having mathematical curiosity and exploring mathematical resources.

Participants explained what had made these particular moments special for them. They described their trainees: developing confidence and a ‘can do’ attitude; feeling supported; succeeding and gaining a sense of achievement. Participants identified instances of managing being scared; being newly confident, comfortable and calm; feeling motivated to learn mathematics; experiencing enjoyment, fun and excitement; being pleased and feeling good.

Participants further identified how other people had contributed to the success of these particular moments. They cited examples of learners being equal partners, open to doing extra work and willing to try, and learners passing their exams. They described positive feedback about their work as emergent coaches. They described other course members as enjoying the course, discussing it at work and supporting each other and their family members being interested.

Participants also discussed their own role as coaches as including: recognising and listening to learners’ anxieties; using mathematical resilience skills with learners, colleagues and family; feeling confident to support learners; feeling motivated, enthusiastic and curious to learn mathematics. They saw their new skills as transferable into other aspects of their lives. They wanted us to emphasise that the course is about mathematical resilience, not mathematics.

## Discussion

There were six features of the course that were particularly valued by the participants. Firstly, the learning environment was experienced as conducive to learning. The participants said that they felt safe, worked together as a collective and in communal activity, had fun and enjoyed the learning and experienced success and achievement. Secondly, the participants reported that they valued the affective aspects of learning which were attended to by giving participants opportunities to experience and to express their emotions in a safe way and to identify strategies for managing their emotions. This feature enabled the participants to progress from unproductive anxiety to productive learning. Thirdly, the participants valued the provision of mathematics tasks that they found to be challenging, fun, interesting and relevant. Fourthly, they valued the opportunity to learn resilience skills. Fifthly, they valued learning coaching skills and using tools and tactics applicable to the learning of mathematics. Lastly, they valued having time to reflect on their learning on the course.

The findings from this pilot course confirm the success of our course design, which was rooted in research evidence. The recommendations from the evidence are that further courses be designed to explicitly build the six features described above into the delivery. Furthermore time was shown to be crucial in developing a community of practice, a course such as this cannot be short. The evidence from observations was that, by week three, the group was beginning to function effectively as a community of practice. The data confirms that, in order to see themselves as a potential coach, an individual first needs to develop their own personal mathematical resilience. By working through their own anxieties and any negative stance towards mathematics in a safe and collaborative environment, the participants were enabled to develop their ability to see themselves as coaches. An important outcome was that an environment that enables an individual to develop as a coach for mathematical resilience will need to expose participants to mathematical ideas. Participants had to be able to consider and manage their own reactions to mathematical ideas in order to reflect on how to help someone else find the resources to overcome barriers to learning mathematics.

The outcomes demonstrated that there were several other particularly significant ingredients to this course design, each of which will be examined in further detail below.

Dual leadership. Two leaders with different kinds of expertise were used in the pilot. The two kinds of expertise were clearly distinct and the course structure modelled an essential feature of coaches for mathematical resilience that they do not need to ‘know the mathematics’. For example, the expert coach focused on attitudes, skills and dynamics of coaching, and being mathematically resilient; she was not a mathematics specialist. In contrast, the mathematics expert focused on providing engaging, accessible mathematical tasks to create the opportunity to undertake mathematical activity starting from where the participants were at the time, and leading them into areas of risk-taking to achieve mathematical success, often known as ‘low threshold, high ceiling tasks’. The mathematical resilience model led to the additional significant elements described in the following sub-sections.

Growth zone model. The growth zone model provided a language for the participants to become aware of and express their own feelings and emotions as they worked mathematically with the tasks. It allowed discussion of the waves of emotions that many people feel when faced with mathematical thinking, and it encouraged the participants to express what they were thinking and to consider how to return to a ‘safe zone’ where learning could happen. As the participants became aware of themselves undergoing their own ‘zonal’ experiences the more they could control their emotions and stay within a learning zone. The participants experienced the emotions expressed by the zones whilst safely supported by the coach and each other and were therefore able to overcome any panic and anxiety they experienced. The participants thereby developed their understanding of what their learners might experience, growing their ability to support other learners managing the affective aspects of learning mathematics.

The participants used the construct of zones in reflecting on experiences; according to one participant, she “can do more with learners even those who are red on maths, [I] can show and support them how to access [the internet] because I have done it myself”.

Another participant used the zones to describe her feelings when asked to carry out a task involving unfamiliar terminology: “That word [net] put me into red” – there was a strong implication of associations with powerful emotions behind the word ‘red’ here.

A participant used the RAG zones when describing working with a new learner; “they immediately went into red when discussing maths; after a little bit of coaching ... they moved into their amber zone”. Another described a “man distraught about needing to pass a maths test”. She asked him ‘what is stopping you?’ He worried ‘do I need therapy?’ She then used the RAG zone model; he understood immediately and used it to communicate how he was feeling, giving further evidence that the RAG zones are useful for communicating and dealing with distress so that the learner can return to a learning (amber) state.

One participant said she did not “have to understand why someone is in red”. The idea of a red zone was used to enable experiences of distress to be easily communicated. Being in the “red zone” indicates that the person’s capacity to listen may be impaired as the brain is likely to be in a state of fight, flight or freeze. If a learner is unable to communicate their distress, a teacher or coach may not become aware that their talking is not being heard. Thus enabling ease of communicating distress is important so that the person can be helped to feel comfortable again and then move cautiously back into the growth zone.

One participant described her organisation’s reaction to her description of the growth zone model, they were “considering using it so that [all] our learners are less excluded from lessons”. Another described that “at work, when I talked about maths people used to glaze over; now I talk about RAG zones and they are interested. They recognise the fear they have of maths and how the red, amber and green cards are helping learners.”

Developing a community of practice. The need for conjoint agency (Markus & Kitayama, 1991) was explicitly referred to during the course, using analogies such as a group going safely on a mountain trek, rather than being in a race. By using such analogies it was conveyed that the learners have shared responsibility for each other’s learning, and that they had shared responsibility for keeping each other safe when embarking on mathematical challenges. Discussion of these ideas was built into the course. In the first session, each participants’ hopes and fears were focused on, and the notion of growth zones were introduced, before collaboratively developing ground rules for subsequent sessions.

The ground rules developed by the participants were: be honest if you are struggling; respect other people’s feelings and current understanding; keep things said or done within the group to keep things safe; help each other and offer help; laugh with one another, not at; the desired outcome is that we all get there – we don’t leave anyone behind; we act as a support network; things we say are temporary offerings; look after yourself; start from where we are; HAVE FUN!”. As an example of this working in practice, one participant shared that “Last week I went into red and the group got me through; I stayed in amber this week because I knew the group would support me and I wouldn’t be left behind.” Other participants went into red quite often throughout the course, showing the red card, but gradually the initial red card would change to amber and comments were made such as ‘[I had a] memory of red but I am safe here’.

This emphasis on building a supportive learning community, was intended to foster curiosity to replace fear, and to encourage the participants to take risks. The mathematics expert offered tasks that built on participants’ innate and developed capacities for mathematics. We had envisioned that to build a community of practice would take time, thus, seeking to ensure inclusion for all participants, no matter how anxious they were about mathematics.

One of the fundamental tasks in building a mathematical community of practice is to develop a shared understanding of language because it is this that allows mathematical thoughts to be shared and explored (Johnston-Wilder & Lee, 2008). Thus, using mathematical language within a learning community is an important part of developing mathematical resilience.

The use of specialised mathematical language is ultimately necessary to work effectively within a variety of mathematical communities of practice (Lee, 2006). Often learners do not learn to use specialised mathematical vocabulary themselves when in school and this can become a serious impediment to later inclusion and learning. A further benefit to using the conventionally accepted expressions of mathematics is that in using those expressions, a person is accorded the status of a possessor of mathematical knowledge (Gergen, 1995). In order to be inclusive, the specialised mathematical terminology were described in this course as a mathematician’s dialect.

To enable the participants to develop their own mathematical dialect, and their awareness of the use of mathematics in everyday life, the course was designed the course to build connections between the mathematician’s ‘dialect’ and the dialect used by the participants in their everyday lives when thinking mathematically. For example terms such as ‘net’ are used very specifically in the mathematics dialect; the idea of a two dimensional pattern for a three dimensional object is common in various everyday activities, but the term ‘net’ is often used to mean something very different. Familiar topics were used, such as preparing a meal and planning a journey, to explore participants’ existing mathematical thinking and their existing dialect, introducing conventional mathematical dialect as appropriate. For example connections were made between the mathematical term ‘probability’ and the term ‘risk’ as in risk-analysis. We contend that using the notion of dialect undermines the notion that personal words are ‘wrong’, reduces the hegemony of conventional ideas about mathematics and increases the accessibility of mathematical ways of thinking. The mathematical tasks were carefully chosen to be accessible, open and student-centred, to support inclusion and agency. One example, which was well received, was four 4s. Participants were encouraged to collaborate inside and outside the sessions on completing a grid of numbers from 1 to 100 using just four fours and mathematical symbols. For example, 4 + 4 + 4/4 = 9.

Participants started to ask question such as: What is it about the question that is excluding you? How can the language be changed? Initially, participants found that words which were used in a specialised way, such as ‘net’, contributed to them feeling excluded. Gradually they began to demonstrate agency – highlighting words that they didn’t know or things they needed to find out, rather than remaining helpless. Experiences of being excluded have a tendency to leave wounds – the natural human disposition is to be part of a group of two or more. Gradually, the whole group began to feel included, as expressed by the participant who said “I feel more confident, as if a barrier is slowly slipping down and I am not backing away from the maths”

## Conclusion

In this paper, we have explored participants’ reactions to their involvement in a pilot course offering a foundation qualification as a coach for mathematical resilience. The participants were at the heart of the ‘mathematics problem’ working as trainers within industry, with apprentices who had some mathematics qualifications from their time in schools, but who needed to show themselves to be able to make use of mathematics in a work environment. They all felt their lack of preparedness to take on the role of ‘supporting’ these apprentices in passing the mathematics element of their apprenticeship frameworks, hence their attendance on the course. However many of the participants demonstrated

There is a very real “mathematics problem”, which literature makes clear (e.g. Norris 2012 and ACME 2012) current approaches to teaching mathematics do not address for a significant proportion of the UK and US populations. It appears from this evidence that the “problem” is the prevalence of mathematical anxiety, helplessness and avoidance.

In this paper, we have explored one approach to helping people in work-based learning to overcome their reluctance to engage with mathematical learning, that of improving supporters ability to coach learners to become mathematically resilient. That the participants in the project had first to overcome their own emotional response to being asked to work with mathematical ideas illustrates how widespread mathematical anxiety and avoidance is. Once the participants had begun to find ways to manage their own ‘bad stress’ response, they began to see that it was possible for them to work with mathematical ideas with curiosity and persistence and to know that there were ways to enjoy mathematical thinking when in a supportive environment. They began to develop mathematical resilience themselves. A resilient stance to mathematics which seems to be an essential part of being a mathematics resilience coach. Such a coach does not need to be ‘expert’ at mathematics, rather they need to experience for themselves that mathematical knowledge is not fixed but rather that it can be grown, that there are resources available to help, that talking and collaborating is likely to yield results and that making mistakes is an inevitable part of the process.

The participants in this course were already resilient in many parts of their lives, they were working successfully in work-based learning and offering support and training to apprentices at that place of work. They recognized that mathematics was an exception to their overall resilience and the initial mathematical tasks were approached in fear and trepidation. Nevertheless, as the course ended, participants felt they had the tools to begin to support learners in learning and using mathematics, and were ready to start Level 2. As such, the course was a success. More people, both participants and those with whom they interact successfully, will now use and not avoid mathematical ideas in the workplace, and be coached to use the ‘everyday’ resilience that people have, but do not use when faced with mathematics. Instead of fear, avoidance and learned helplessness, working to develop mathematical resilience offers a ‘can do’ attitude that must be important for people learning and using mathematics within the workplace.

Thus the study revealed that if people are going to be able to learn and use mathematics in the workplace they will need to overcome barriers in learning mathematics. The idea of coaches is an appealing one both because of the lack of well-qualified teachers but also possibly more importantly that ability of coaches to help manage the negative affective aspects of learning mathematics that the way that mathematics has traditionally been taught has continued to allow to develop. The design of this pilot course appears to have worked in developing people who have grown their own mathematical resilience and who see themselves as able to help others learn mathematics. The important aspects in achieving the course aim were the dual leadership, enabling the participants to see coaching and mathematics s separate; the growth zone model; allowing an encouraging expression of feelings when learning mathematics and the development of the group as a community with a common practice.

This study has further revealed some important aspects of mathematical resilience, the feelings of ownership, of both “I did that” and “I can do that” that coaches can help establish in learners are key in enabling mathematical learning. This is not the same as “I got ten ticks”, the it is the “*breathe, find out, read the question, check the task, ask questions, take a break, try a little harder, struggle for longer or shorter depending on my emotional state, learn by my mistakes*” type of success which matters. Such successes are often thin on the ground when all that is offered is an impoverished mathematics curriculum where mathematics is always broken down into small chunks that can be memorised and never used to explore ideas, model situations and solve problems. A further aspect of developing mathematical resilience evidenced by this study is that “*when you are learning, you need time and opportunity to try out*”; rushing through ideas and aiming for coverage develop anxiety and not the confident learning that is an indicator of mathematical resilience. Time to think and reason along with the idea that everyone can succeed, are important aspects of developing the resilience that allows success in mathematical studies.

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