DEVELOPING PEER COACHING FOR MATHEMATICAL RESILIENCE IN POST-16 STUDENTS WHO ARE ENCOUNTERING MATHEMATICS IN OTHER SUBJECTS

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Abstract

A significant number of students are known to have mathematics anxiety (Johnston-Wilder et al 2014). When such students begin to specialise, they may deliberately choose courses to keep mathematical content to a minimum or seek to avoid it altogether. Nevertheless, many courses employ more mathematics than expected, requiring students to apply mathematical thinking or mathematical ideas in their work, and this can often result in significant distress. Typically students feel alone in facing such issues as mathematics anxiety. In previous work, we used the term 'mathematical resilience' to describe the positive stance towards mathematics that enables learners to overcome barriers and set-backs that can be part of learning mathematics. In this paper, we present and discuss the outcomes of a course in 'peer coaching for mathematical resilience' for students who have chosen not to take courses with explicit mathematics, but who continue to encounter mathematics within other subjects.

Mathematical resilience can be engineered by a strategic and explicit focus on the culture of learning mathematics within both formal and informal learning environments. Such a culture can be engineered by using coaches specifically trained to support emergent resilience. We aimed to develop a group of peer coaches in school, who support each other and their peers to develop mathematical resilience. Coaches for mathematical resilience develop a culture of 'can do' mathematics which works to counter the prevalent culture of mathematics helplessness and mathematics anxiety in the general population. The coaches are not required to know the answer but rather to know ways that might yield an understanding of the mathematical ideas involved which thus leads to an answer.

A previous paper described the development, pilot and outcomes of the level 1 Coaching for Mathematical Resilience course, in which participants were adult trainers, mostly maths-anxious, working in an apprenticeship context. This paper discusses the outcomes of the same course for a group of 5 school students (Sept to Nov 2014), who volunteered to become 'peer coaches for mathematical resilience' in school. The course provided a safe and collaborative working environment in which the school students learned to manage their own reactions to mathematical ideas, to explore choices and to reflect on how to support someone else to find the resources to overcome their own barriers to learning mathematics. The data confirm that once a school student has begun to develop their own personal mathematical resilience, they can successfully coach themselves and others to manage their anxiety and develop as resilient learners and users of mathematics. Learner outcomes improved noticeably as a result.

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

1 UNDERSTANDING ‘THE MATHEMATICS PROBLEM’ FROM AN AFFECTIVE VIEWPOINT

According to psychological research (for example, [1]), repeated exposure to unpredictable and inescapable stress can lead to learned helplessness, anxiety, inactivity, and fear. We consider the mathematics problem as people avoiding mathematics in order to avoid a repeat of previous unpredictable or inescapable stressors. We propose that this is not in the nature of mathematics itself, but a result of one or many negative experiences that lead to mathematical avoidance as a form of psychological protection.

1.1 Good stress, bad stress

Stress experienced by a learner can be productive, “good stress”, based on 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 may seem exciting. However, situations involving more prolonged, repeated, or chronic stress, which may be experienced as uncontrollable or unpredictable, involving a lower sense of mastery or poor adaptability, lead to a greater 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 [2])

1.2 Mathematical resilience

Building on a generic understanding of academic resilience, and on neurobiological understanding of affect as an integral part of cognition [3], we have built a pragmatic description of ‘mathematical resilience’ [4]. We have found that mathematical resilience can be developed in people who have experienced previous mathematical exclusion or stress, through a strategic and explicit focus on the culture of learning mathematics within both formal and informal learning environments. People who were mathematics-avoidant can become curious, become aware of their feelings, develop an internal locus of control, develop a strong social learning network and learn to seek and give help.

Drawing upon Dweck’s notion of growth mindset [5], we have found it helpful for learners and coaches to think of mathematical resilience as what is needed to stay, safely, as long as possible, in the ‘growth zone’. This zone is immediately beyond what a person is able to do reliably, without aid or support. The growth zone model is further expanded in a previous conference paper [6], and the diagram is reproduced here as Fig. 1.

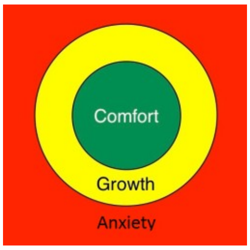


Figure 1: The growth zone model

When in the ‘growth zone’, new learning happens. In the growth zone, it should be experienced as acceptable, indeed expected, to make mistakes, go down dead-ends, experience some failure, require support, get stuck and find activity challenging and tiring. The learner needs to know in advance that being in the growth zone may trigger productive levels of adrenalin, which might develop feelings of excitement or mild anxiety. The learning environment needed is one of trust, courage, articulation, collaboration and persistence. Ideally, students will feel motivated and appropriately supported – and have opportunity – to enter their growth zone often.

Beyond the growth zone is the danger zone or ‘anxiety zone’, 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 extremes, no useful learning taking place, and learners increasingly use maladaptive coping strategies of avoidance, helplessness or even paralysis. Since so much of everyday life uses mathematics, learners need to learn to safeguard themselves in ways that encourage engagement with the mathematics and learn find a way back out of the danger zone into the growth zone.

We propose that positive mathematics experiences, together with a language of risk awareness and risk management can help learners to develop risk taking and risk management processes in their learning of mathematics, which then lead to increased time in the mathematical growth zone. Learners need to experience protective factors: connection, competence, opportunities for participation and contribution. This does not all need to happen within the mathematics lesson per se to impact upon mathematical resilience.

2 DEVELOPING PEER COACHES TO SUPPORT EMERGENT MATHEMATICAL RESILIENCE

We envisage peer coaches for mathematical resilience helping peers (and themselves) to recognise what zone they are in — danger, mathematical growth zone or cruising — and encouraging peers to value challenge and to manage the emotions involved, helping them to think about and use resilient learning ideas when facing difficulties or taking action to safeguard themselves. A coach will support, respect, listen, be compassionate, validate, model resiliency, and refrain from judging, enabling a coachee to feel safe in exploring, thinking through options [7] and taking managed risks in order to grow mathematical capability. Peer coaches learn to use a language that allows peers to recognise and articulate what degree of challenge they are facing; encourage increasing independence and agency; model a strategy or model being part of a community of practice; know how to access help. Coaches develop a culture of ‘can do’ mathematics which works to counter a prevalent culture of mathematics helplessness and mathematics anxiety when faced with mathematical ideas. The coaches are not required to know the mathematics but rather to develop the peer’s ability to recognize options and actions that might yield an understanding of the mathematical ideas involved and thus lead to an answer.

Any person, ‘mathematical’ or not, can support others with mathematics by understanding how each of the zones described above is experienced, and by encouraging explicitly the development of mathematical resilience. The work described here is focused on developing peer coaches. This paper discusses the outcomes of a course designed to develop ‘peer coaches for mathematical resilience’; the course ran from September to December 2014. Initially, the course recruited 12 participants who were all taking A-level subjects that did not explicitly include mathematics. According to one of these participants, “The way it was presented to us at the start was that when we were given the letters we didn’t have a choice. ... Quite a few people who have left now were forced to come along.” The paper focuses on the 5 students who stayed to complete the course voluntarily; the culture of coaching assumes a two-sided contract, not coercion.

2.1 Significant ingredients

The Coaching for Mathematical Resilience Course [4] combines two main features: firstly, coaching skills and attitudes, which reflect the principles of developing resilience in self and peers, and, secondly, the development of a personal ‘can do’ approach to mathematical challenges (see Fig. 2). Thus, as before, the course was jointly led by an experienced coach and an experienced mathematics teacher. It is important to note that the coach does not need to know any mathematics; the coach focuses on teaching and modelling techniques, skills and dynamics of coaching, on ‘mathematical safe-guarding’ of participants and on being mathematically resilient. The mathematics teacher provides engaging, accessible mathematical tasks to create the opportunity to undertake mathematical activity starting from where the participants are, and leading them into areas of risk-taking to achieve mathematical success and growth.

2.1.1 developing an inclusive community of practice

The underlying theory is one of social constructivism, in that many learners do better if they learn in groups, with ‘conjoint agency’ [8]; ’conjoint agency’ expresses the idea that participants explicitly trust and include one another in the learning process, and share responsibility for keeping each other safe when embarking on mathematical challenges, explicit trust, and inclusion. This was built into the course from the start with a session in which participants described their hopes and fears for the course, and their good and bad previous experiences of mathematics, before collaboratively developing ground rules of trust for subsequent sessions.

The hopes that students articulated were: to learn maths skills to use in other lessons; to put anxiety behind me; to learn things that help me to succeed in my A levels; not to feel inept in maths; to remember methods that suit me. The fears they articulated related to: being embarrassed; not learning any maths; looking stupid; [the course] not helping; being laughed at; my dyslexia and anxiety getting in the way; muddling up my numbers; being bored. One student expressed concern at ‘having to be socially active’; with hindsight that was a concern to which we did not pay sufficient attention.

The good experiences they remembered included: successes (“you’re right”; getting my grade B; finally achieved my C!); a lovely teacher. One participant could not remember a single good maths experience. The bad experiences they remembered included: being shamed (singled out, compared with siblings, mimicked); being rushed and overloaded with information; feeling excluded; maths not being related to the real world or interesting; not being listened to; not feeling motivated; feeling unable to ask questions; not understanding; being told to “give an answer I didn’t know”. One participant noted: “maths is limiting me now in a subject I am now taking”.

These responses were indicative of a significant level of experiences of shame, anxiety, and exclusion around mathematics, in addition to mathematics being experienced as TIRED: tedious, isolated, rote, elitist and de-personalised [9].

In the light of these experiences, the ground rules developed by the participants expected participants to: be OK to say ‘I don’t know’; ask for help/explanation/guidance; be respectful; be considerate, caring, thoughtful, acknowledging; be empathetic; listen; be supportive; encourage; reassure; involve everyone; be inclusive; treat everyone equally and diversely; [engage in] teamwork; keep things confidential; ask questions; make an effort; take risks; be open minded; give positive, constructive feedback; aim for success; make sure everyone is OK; be willing to help [each other].

One of the fundamental tasks in building an inclusive mathematical community of practice is to have a shared understanding of language because it is this that allows mathematical thoughts to be shared and explored [10] collaboratively. Thus, making mathematical language accessible within a learning community is an important part of developing mathematical resilience. We used familiar topics, such as preparing a meal and planning a journey, to explore participants’ existing mathematical thinking and their personal dialect, introducing the ‘dialect of a mathematician’ as appropriate. We contend that using the notion of ‘dialect’ undermines the notion that personal words are ‘wrong’, reduces the hegemony of mathematics teachers and increases the accessibility of mathematical terms. So, for example, we explored connections between ‘probability’ and the everyday term ‘risk’.

The emphasis on a supportive learning community, thus made explicit early on in the course, was intended to foster curiosity in place of fear, to encourage participants to take risks and to encourage shared responsibility for learning in place of embarrassment about making mistakes. We had envisioned that to build a community of practice would take time. As a precaution, we planned the course over eight half-day sessions. This is shorter than the course described previously [4], because the students were all from the same school; we reasoned that they would build a community more quickly than participants from different institutions.

2.1.2 growth zone model

For the growth zone model to be effective, and for participants to appreciate the significance of this model, we deemed it important for participants to become aware of themselves undergoing their own zone experiences. The philosophy was that participants would experience the zones, become more aware of their feelings and be explicitly and safely supported, both by the coach and by each other, to overcome any panic and anxiety they experienced, so they could be enabled to understand what their peers might experience and to support them with managing the affective aspects of learning mathematics.

Initially, participants were introduced to the growth zone construct and invited to use words to describe how the zones had felt based on past experience. The students used the following words to describe their experiences in the different zones. They described being in the green zone as feeling: good; relaxed; fine; confident; happy; comfortable; OK; calm; chilled; safe. They described being in the red zone as feeling: stupid; scared; angry; frustrated; limited; threatened; panicked; tearful; upset; confused; anxious; annoyed; dizzy; shamed and also used the words freeze and mental block.

After some reflection, and in some cases being encouraged to think of contexts other than learning mathematics, they described being in the growth zone as feeling: curious; excited; apprehensive;

unsure; attentive; challenged; contemplating; concentrating; alert; queasy; on edge; reluctant; cautious; shaky; unsteady and that often support was needed.

The students were then given coloured cards and were encouraged to show which zone they were in whilst working on a mathematical task, having established the ground rules that made this a safe environment in which to do so.

2.1.3 fostering personal agency

In general, people are only prepared to work hard and to struggle in order to develop new knowledge and skills, when they feel motivated and able to safeguard themselves from perceived risks.

"What has emerged from the collective lines of research is the understanding that the tendency of events to subsequently trigger some analogue of anxiety or negative affect is dependent to some degree on the amount of control the organism experiences over those events." [11]

One element of the course that supported the development of personal agency was consideration of options available. This had two aspects; the first was to examine options to support the "can–do" approach to mathematical challenge. The second, and in many ways more important, was to consider options available for the participants to "stay safe", that is to say move from the 'red' zone back to the 'amber' or even 'green' zone. This exercise resulted in students suggesting the following techniques: distraction; thinking back to an event where you felt confident and capable; imagining being successful at this problem; patting yourself on the back at each stage; positive self-talk; rewards for small steps; asking for feedback; asking a friend or coach for help.

We use the coaching model proposed by Egan [7] to encourage the development of effective personal agency. Students learned to coach themselves and others to explore a situation, consider options and then set and review goals, acknowledging how they might address hindrances and sabotage progress.

2.1.4 increasing awareness of use of maths in everyday life

One of the fundamental motivators of human behaviour is sense-making [12]. To encourage sense-making, we drew upon Bruner's [13] hierarchy of accessibility: enactive, iconic, symbolic. One particularly successful example of this was an activity in which students were given boxes of coloured sweets called 'Smarties' and asked to make first a bar chart and then a pie chart to represent the distribution of colours in their own box, and to compare with the contents in each other's boxes. The students found this activity very significant. One said:

"A few weeks ago we did pie charts. I have never been able to do pie charts in my entire life. We did them with Smarties and fruit pastilles, cos of all the different colours I can now think, looking at how we did that, well that is what a pie chart should look like, if I can just work out all the segments I kinda relate it back to the Smarties. Ok the Smarties. That's how I did it now I gotta do my bit and carry it over like that that kinda reinforces that I couldn't do it before but if I look at it a different way I can do it now."

Another said: "You had brought in the skittles and the various sweets. That kind of spurred me to do more work. It was such a physical, down to earth factor that was really contextual to me. Then we made the pie-charts with them. I really could understand it. It wasn't lines on a 2D page it was a 3D object that I am very familiar with. So I felt positive about it. I felt I could do it."

We suggest that any mathematical concept can be made accessible by appropriate enactive tasks, if an iconic or symbolic version is not yet accessible, and that there is no reason for anyone to be excluded from mathematical thinking. Coaches may not be aware of specific appropriate tasks, but be aware of the possibility of asking the teacher for such a task.

In the following section, we present an evaluation of the course.

3 EVALUATION

The course provided a safe and collaborative working environment in which the school students learned to manage their own reactions to mathematical ideas, to explore choices and to reflect on how to support someone else to find the resources to overcome their own barriers to learning mathematics. In evaluating the impact of this course we draw upon data provided by students during the course, post-course student interviews and progress data provided by the school. The data confirm that once a school student has begun to develop their own personal mathematical resilience, they can successfully coach themselves and others to manage their anxiety and develop as resilient learners and users of mathematics. Learner outcomes improved noticeably as a result, as we will evidence.

3.1 Safe and collaborative working environment

The students responded well to the explicit approach to building a safe and collaborative working environment. One student said: "At the start, I was quite rigid, [thinking] I don't want to be here. After 10, 20 minutes, I was thinking: 'This is not going to be so bad because we are not just sitting here doing maths, we are sat in a circle looking at everyone and discussing how we feel about maths and anxiety, and ... this is actually pretty good. I am actually enjoying this.'"

Another student compared the course with their previous experience of learning mathematics: "I remember when I was doing GCSE maths. I didn't want to ask the teacher questions or anything. I felt I would be laughed at if I got something wrong. That really restricts your learning. In the safe learning environment, you can ask questions and make mistakes so you can learn because that is part of learning. It was better to have a positive learning environment where you can make mistakes; otherwise you restrict yourself and don't really go into the amber zone. I can vaguely remember that, when I was doing maths, if I didn't understand something I just wouldn't ask because I didn't want to be ridiculed. [In the sessions, I felt safe] all the time. I was very open in the sessions. I don't think there's been a time that I felt I couldn't ask. If I don't understand something I just ask you about it. Like with the box plots. I asked what they are used for, and stuff like that. In the session today ... I admitted at the start that I didn't understand the question. I wouldn't say that in a maths lesson. Because it was a positive learning environment I could say that."

It is interesting to note how the student uses the newly introduced language of the growth/amber zone to articulate understanding of their experience of improved progress and the role of personal agency such as asking questions in order to learn.

Student F had had very extreme negative experiences of maths, describes it as soul-destroying. They began the course "feeling stupid and terrible at maths." Initially they exhibited poor behaviour, calling those who took part "naffy". With hindsight, their behaviour could be identified as arising from self-protection by avoidance. Early on, they recognised the extent of their stress, and the importance of a coffee break to help manage. An early personal goal they set was very cautious: "Might get help. Might." To which they later added: "Try not to get stressed and unhappy."

Slowly F began to engage by asking trusted people from the group for help. They started to feel that the work was accessible. They also felt included: "I felt part of the group and not lagging behind", even though he still believed the others were all "good at maths".

By week 7, student F wrote that they were feeling "like maths is a barrier I have started to overcome" and that they were experiencing "understanding and not hating maths".

3.2 Self-coaching

The students learned to recognise that, when faced with mathematical difficulty, there were always options available, including, for example: asking questions, looking up on the internet, asking advice from teachers, friends, family or web groups. In an interview, one student said: "Just because you think you can't do something doesn't mean you can't do it whatsoever. As long as you've got the right people around you and the right resources you can [do it]. It's not just "I can't". Also that if you are in your red zone you can always come back. You just need to relax. You need to have different strategies to get yourself out."

Another student illustrated her new self-coaching skills with reference to a chemistry test. "Before it, I was going into the amber slash red zone and thinking I couldn't do it. Because I'd been in the maths session and we got taught how to deal with it, I reassured myself, that because I did the work I could have a good go at it and if I just tried it, then I'd done my best. I think it went ok. I felt relieved instead of feeling anxious about it."

The students found the notion of the red, amber and green zones helpful because "you can identify problems that you are having and actually deal with them. So, if you are not feeling confident about something you can address it, rather than just leaving it and saying that you can't do something."

In the final interview, student F described an example of newly developed self-coaching and resilience:

“My dad at the restaurant jokingly put his hand over how much the meal was and asked me how much was it. As you know a receipt is a very blunt back and white with lots of numbers. I kind of panicked ...I said I can’t do that. My dad ... said ... just start from the top. I thought I have been learning these coaching skills I should probably start using them now, on me ... my brother is also not amazing at maths, I said come help me. We worked on it together. Pushed forward on it. We got it wrong a few times. Said no go back. We went wrong somewhere. We didn’t spend hours on it. It was a fun little thing, when I was in red zone, and then I kind of got him to help me, and when he helped me then I could help him and we bounced off each other with coaching skills. I felt good because it I thought I would never be able to do this, but then I got help. He didn’t know what he was doing I didn’t know what I was doing but we helped each other. We finally started getting it.”

In this way, the skills that foster mathematical resilience can be shared, with family members and peers, and slowly, a step at a time, a culture of mathematical inclusion can grow.

3.3 Coaching others, sometimes without knowing the maths

According to one student, “When it comes to coaching, I do a lot of ... things. A friend comes to me with her work. She says ‘I don’t get it. I just don’t get it.’ I will sit down and help her out. I will ask ‘What have you been learning? How have you been taught to do this? What don’t you understand?’ I ask her simple questions and try to help her find a way to figure it out.”

It is important to note that the students did not always know the maths involved but were still able to coach. One student emphasised the coach role as giving “confidence in myself”.

Student F, painfully aware of their own lack of understanding of GCSE maths, had particularly vivid experiences of coaching success. For example, F described a time when a friend was doing an advanced maths question. “He didn’t know what he was doing. He was reluctant to go to the back of the book cos he wanted to work it out for himself. Even though this was completely alien to me, I could still say: what does the question want you to do? How are you feeling? What do you actually have to do? Can you go back and look at it and find out what evidence was given to you and put that forward to make a kind of instruction for yourself. And eventually he got it. And I felt like even though I was completely incapable of helping with the question, I still helped him. When he explained it suddenly it started ticking [for him]. He was quite happy [with my help]. He was stressed in that he didn’t know what he was doing and instead of focussing on the question itself he was looking at these big numbers and weird symbols. That was quite frankly scary. I was focussing on the words and the more safe areas, pulling that forward. Instead of being not reassuring and going ‘wow, that’s terrible’, I said ‘instead of giving up now, look at the question. What can you do?’”

Such an experience has had a profound effect on student F, who now feels able to contribute more effectively within the advanced studies cohort and has experienced a significant improvement in performance, as we discuss in the next section.

3.4 Learner outcomes improved noticeably as a result.

Due to the small-scale nature of the intervention, it is not our intention to make statistical claims from the data. However, we are cautiously pleased to report that by the end of the autumn term, the value-added score we were given by the school for the participants in CfMR course was +0.9 compared with a year group average of +0.3. After the summer exam results were available, the school reported that they were pleased with the impact the programme had had for the participants. In particular, the fact that “the pupils on vocational courses made equivalent progress in their academic subjects to their more confident peers” suggests that the CfMR programme had the intended impact.

In more detail, four of the five students gained very positive value-added scores compared with their peers at the end of the year (see Table 1).

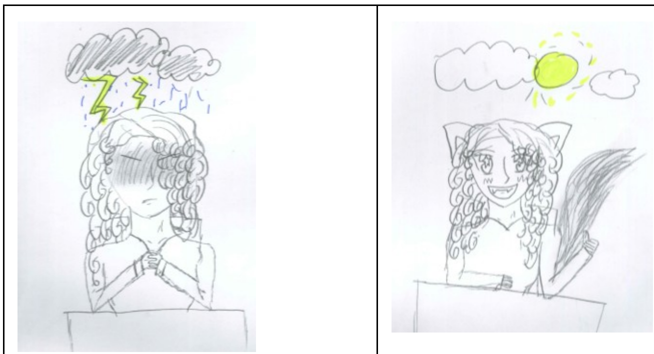
Table 1: value-added scores of participants compared with year average

Academic course results:		Vocational course results:	
Student C	+0.13	Student B:	+5.49
Student F	+0.92	Student D:	+3.8
Year average	- 0.06	Year average	+1.5

The non-positive impact of the course on Student G needs further investigation. In the interim we should be more mindful about the effect such an intervention could have on very shy students who have, in the past, tended to avoid social activity.

4 DISCUSSION AND CONCLUSION

The students were asked to illustrate their experiences of developing mathematical resilience. The illustrations were of transformation, from helplessness, distress or failure to a new ‘can-do’ attitude in which personal agency was expected to make experiences of mathematics meaningful, manageable and comprehensible [12].



Before

After

Figure 2: Student illustration of transformation from helplessness to mathematical resilience

The transformations experienced by the participants have impacted on their academic and vocational performance, and this impact has been recognised both by the individuals personally, and by the school. Further, larger scale studies are needed to establish the statistical significance of the improvements that can be achieved.

4.1 Developing personal mathematical resilience and self-coaching skills

The notion of mathematical resilience as personal safe-guarding in the mathematical growth zone, and the language of red, amber and green zones to describe affective responses to situations, seem to have been very supportive to school students of this age, as they were to the older coaches we worked with previously [4], both in mathematics-specific situations and more generally. The key ideas of growth mindset, inclusion, personal value (or meaningfulness) and personal agency have been a useful pragmatic foundation to the course.

The course provided a safe and collaborative working environment, conducive to learning effectively. Participants reported that they: felt safe; worked together as a collective and in communal activity; had fun and enjoyed the learning; experienced success and achievement.

The issue of anxiety and fear around mathematics, which the construct of Mathematical Resilience was developed to combat, is clearly illustrated in this paper. There is a strong sense in the data of participants having to overcome significant initial hurdles to achieve a positive outcome. Feelings of historic dread, anxiety, fear and historic exclusion permeate the data. The growing sense of achievement, confidence, value and self-esteem, as the participants worked through the course and understood that they could have a different stance to mathematics and help others, provides a stark contrast to some of their initial attitudes. There is also evidence that participants have begun successfully to transfer some lessons from the course to their lives outside school.

As peer coaches, the students learned to remain outwardly calm, protecting their peers by managing their own anxiety about mathematics. The coach does not “show how”; they encourage personal agency *by asking question such as, ‘what could you do?*’

CfMR coaches learn to understand the emotions that learners can feel and how coaching can help. The data confirms that once an individual coach has begun to develop their own personal mathematical resilience, worked through their own anxieties and negative stance towards mathematics in a safe and collaborative environment, they can then learn to coach themselves and peers to develop as resilient learners of mathematics. Importantly, when the coach learns not to take any responsibility for the mathematics, but rather to focus on the learning skills and wellbeing of others, outcomes are improved.

4.2 How much time?

Having established in several small-scale studies that the intervention is effective at helping participants learn to manage mathematics anxiety, and to improve progression in mathematics, we are often asked “can the intervention be shorter (and cheaper)?” We note here that whilst one participant felt very positive right from the beginning, and another by week 4, at least two of the participants only found themselves becoming increasingly positive towards the end, needing both time over weeks and time to reflect in sessions.

One student, who said they were most positive towards the end, described how important were the times built in for reflection: “When we were tackling maths problems it was quite strenuous but I can reflect on it. I can feel I have achieved something ... [I am] quite positive about what I had learned.”

Another student who said they were most positive at the end reflected upon how they had only recently learned to apply what they had learned in Chemistry: “I had loads chemistry work to do. I thought I just can’t do it. [The coach] showed me a few tricks to get out of the red zone. Then I thought ‘Oh yes. I can really do this now. This is alright.’ I felt quite positive in myself. Usually in Chemistry I’d feel I can’t do anything complicated because I got pretty bad GCSE marks. When I thought, ‘Oh yes, I can do this’, I didn’t have as many negative thoughts like ‘Oh, I can’t. I don’t know how’. [Instead,]I thought ‘I don’t know but I can find out’. Like the anxiety towards the problem itself has just gone.”

We suggest that this is the mechanism behind the improved grades seen in this student’s profile.

4.3 Size of group

We are often asked “what size group works best?” Having established, in several small-scale studies, that the intervention is effective, we can at this stage in our research suggest that appropriate group size is fairly critical. Too small a group does not allow for development of an effectively supportive learning community, but a group can also be too large. One student specifically said they didn’t like too many people at the start: “The medium group felt like a really good group”. For them, the ideal group size would be over six, ideally, for the coach and mathematician, no more than 20.

4.4 Wider applications of self-coaching skills

In the UK there is significant concern about stress levels amongst teenagers. Since we have established, as before [4], the impact of this course on the participants extended more widely than increased academic success in mathematics and associated subjects, it could be suggested that the increased confidence of the participants could be an effective counter-agent to the current stress level experienced by many teenagers.

One student gave the example: “When I go out into town or something, because I have anxiety. I think I can’t go in there there’s too many people. [Now] I say [to myself]: ‘Look you are in red, take a few deep breaths, have a chat with a friend for a minute. Then you will go back to amber and you will be able to do something that you thought you couldn’t do a minute ago because you were just panicking’ Then I say: ‘I’ll give it a shot. I’m not sure if I can do it, but I will give it a try’.”

Another student reflected upon how the new skills would impact on university studies: “I usually can phone [my friend] which will take my mind off something so I’ll go from red to amber and straight back down to green so you just need to find a different way to relax. I think I can take that to university to my studies. ... I can think: ‘Alright, I feel really anxious .... Calm down take a few deep breaths think ok picture yourself completing it and that will take you back down’.”

A third student described how these new skills helped to support their mother with her medication regime when she came out of hospital: “She had to work out how much dosage she needs. She was saying ‘I don’t know what any of this is. I am not a nurse or a doctor. I had no idea.’ I looked at it. I said, ‘It says this’. The ‘how are you feeling?’ question became really, really relevant, because that says how much you need to take. I said ‘what is it asking you to do?’ instead of just telling her, because I can’t always be there to guide her through how much dosage she needs every day”.

These examples indicate that the potential wider impact of the course could be socially significant.

4.5 Final comments from the participants:

We end with the voice of a participant, describing the impact and the experience of mathematical inclusion within the course: “The course you’ve got is brilliant and can cope with people who can tell you what pi is exactly and people who don’t even know what pi is.” And a retrospective comment from one of the first cohort of coaches: “The CfMR was a totally life changing experience for me and I cannot thank you enough for giving me the opportunity and supporting me through it. I actually enjoy maths now.”

We suggest that anyone who has been historically excluded from mathematics, mathematically shamed, or who has developed mathematical anxiety or avoidance to protect themselves from mathematical harm, should be entitled to such a life-changing experience.

REFERENCES

[1] Seligman, M. (2007). The Optimistic Child. New York: Houghton Mifflin.

[2] Sinha, R. (2008). Chronic Stress, Drug Use, and Vulnerability to Addiction. Ann N Y Acad Sci. 1141, pp. 105–130.

[3] Adolphs, R. & Damasio, A. R. (2001). The interaction of affect and cognition: A neurobiological perspective. In J. P. Forgas (Eds.), Handbook of affect and social cognition, pp. 27–49. New Jersey: Lawrence Erlbaum Associates.

[4] Johnston-Wilder, S. and Lee, C. (2010). Mathematical Resilience. Mathematics Teaching 218, pp. 38–41.

[5] Dweck, C. (2000). Self Theories: Their Role in Motivation, Personality and Development. Lillington NC, Psychology Press, Taylor & Francis.

[6] Johnston-Wilder, S., Lee, C., Garton, E., Goodlad, S., Brindley, J. (2013). Developing Coaches for Mathematical Resilience. In Proceedings of 6th International Conference of Education, Research and Innovation, Seville, Spain 18-20 November, 2013, pp. 2326–2333.

[7] Egan, G. (2013). The Skilled Helper: A problem-management and opportunity-development approach to helping. (10th Edition). Belmont, CA: Brooks/Cole.

[8] Markus, H. R. and Kityama, S. (1991). Culture and the Self: implications for cognition, emotion and motivation. Psychological Review 98 (2), pp 224–253.

[9] Nardi, E. and Steward. S. (2003). Is Mathematics T.I.R.E.D.? A profile of quiet disaffection in the secondary mathematics classroom. British Educational Research Journal 29(3): 345–366.

[10] Johnston-Wilder, S. and Lee, C. (2008). Does Articulation Matter when Learning Mathematics? Proceedings of the British Society for Research into Learning Mathematics 28(3), pp 54–59.

[11] Chorpita, B. F., & Barlow, D. H. (1998). The development of anxiety: The role of control in the early environment. Psychological Bulletin, 124, 3–21.

[12] Antonovsky, A. (1987). Unravelling the mystery of health: How people manage stress and stay well. San Francisco: Jossey-Bass

[13] Bruner, J. S. (1966). Toward a Theory of Instruction. Cambridge, MA: Harvard University Press.

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