DEVELOPING COACHES FOR MATHEMATICAL RESILIENCE: LEVEL 2

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Abstract

The construct 'Mathematical Resilience' [1] has been developed to describe a positive stance towards mathematics, one that enables learners to approach mathematical learning in ways which allow them to overcome the barriers and setbacks that are frequently part of learning mathematics for many people. 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. As part of that cultural engineering, the notion of coaches has been specifically developed to support emergent resilience. The work described here is focused on developing coaches who can work beside learners, helping them to conjecture and use resilient learning ideas when facing difficulties in mathematics. Coaches develop a culture of 'can do' mathematics, which works to counter the prevalent culture of mathematics helplessness and mathematics anxiety in the general population when faced with mathematical ideas. The coaches are not required to *know the answer,* but rather to know ways approaches that might yield an understanding of the mathematical ideas involved and thus lead to an answer.

Our previous paper described the outcomes of the level 1 course, in which participants became skilled at peer coaching. This paper discusses the outcomes of the second level part of the pilot course (September to November 2013) designed to develop 'coaches for mathematical resilience', equipped to work with learners who have a mathematics tutor. The 10 participants, who regularly work with apprentices, from a range of age groups, in a work-based environment continued with this second part of the programme. In the Level 1 course, they had worked to develop their knowledge and skills of how to overcome deep-seated antipathy to mathematics in themselves, and in those with whom they work.

The data confirms that once an individual 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 successfully learn to coach learners of mathematics, helping them to become resilient in turn. They become able to help those learners to find or develop the resources and skills to overcome their own barriers to learning mathematics and to manage any anxiety that may be engendered. Importantly, when the coach learns not to take any responsibility for the mathematics, but rather to focus on the learning skills and wellbeing of the learner, the learner outcomes are improved.

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

1 UNDERSTANDING MATHEMATICS UNDER-ACHIEVEMENT FROM AN AFFECTIVE VIEWPOINT

Because the brain is a complex organ, an understanding of some of the functions it performs can be beneficial, especially as some of those functions can get in the way of effective learning. The human brain comprehends multiple inputs at varying levels of awareness, including cognitive, affective and psychomotor. If anything is perceived as a threat, physical or social, there is a series of rapid responses that have kept organisms safe for millions of years: the primitive fight, flight or freeze mechanism. This mechanism can over-ride cognitive function. For complex reasons, many individuals perceive mathematics as a threat and, for many, this results in mathematics causing anxiety which is sometimes acute. If individuals are in an anxious state, it is unlikely they will be able to function well on a cognitive level. Therefore learning can be enhanced when these individuals learn to recognise and manage any adverse personal reactions to mathematics.

Tobias [2] discusses a school in New York that experimented by reducing a group's mathematics teaching by one third; learners used the time that was freed-up to meet with therapists who talked with them about their feelings towards mathematics. The outcome was favourable and learners progressed at a greater rate than when they were having their full complement of lessons. This treatment model has not spread, presumably because of its cost. Coaches for mathematics resilience provide a more cost-effective alternative.

1.1 What does mathematical resilience look like?

Building on modern neurobiological understanding of emotion as an integral attribute of cognition ([3], [4]) and work on academic and psychological resilience, we have built a pragmatic description of 'mathematical resilience' [1]). Mathematical resilience was originally theorised as having 4 factors:

1. The belief that brain capability can be grown;
2. An understanding of the personal value of mathematics;
3. An understanding of how to work at mathematics;
4. An awareness of the support available from peers, other adults, ICT, internet, etc.

Mathematical resilience can be thought of as what is needed to stay safely in the 'growth zone' for as long as possible. This is further expanded in a previous conference paper [5], and the diagram is reproduced here as Fig. 1.

Figure 1: The growth zone model

Briefly, the Growth Zone is conceived as the zone between comfort and anxiety, where the learner faces challenge, with appropriate support; grows within their capabilities, is safe with others; and able to make mistakes and experience some failures as steps towards success. The growth zone is where new learning happens.

The learner needs to know in advance that being in the growth zone may trigger productive levels of adrenalin, not too much, but just right. The physical reaction to challenge is a supporting influence on potential cognitive development, provided the learner feels that any risks are under their control.

1.2 Support to recognise personal growth zones

Working with individuals to support them in recognising the signs and personal reactions that identify red, yellow or green zones helps them to develop a personal understanding and acceptance of how to manage and thus dissipate the anxiety they may feel in approaching mathematical learning. Such support enables individuals to develop an understanding of their reactions and then, with the help and support of a coach, to develop strategies to manage the potentially extreme emotions associated with being in their red zone. In this way, learners can be enabled to go back into the yellow growth zone.

Conversely, by recognizing the emotions associated with the green zone, individuals can expect to be challenged to move into the yellow zone and thus enable meaningful cognitive development. Both scenarios would produce more meaningful learning for every individual who is enabled to take charge of recognizing their emotional state in relation to their personal learning.

1.3 Developing coaches to support emergent mathematical resilience

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, part of the solution lies in developing mathematical resilience in all adults and children outside the mathematics classroom. One proposal for achieving this lies in developing 'coaches for mathematical resilience'. A coach will support, respect, listen, be compassionate, validate, model resiliency, and refrain from judging, enabling a coachee to feel safe in taking risks in order to grow mathematical capability.

Coaches for mathematical resilience help learners to recognise for themselves when they are in their mathematical growth zone, encouraging learners to value the challenges this brings and to manage the emotions involved. Coaches use a language that allows students 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; they know how to access help. Any adult, 'mathematical' or not, can support a learner of mathematics by understanding 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 a language to express resilient learning ideas when facing difficulties in mathematics. Coaches develop a culture of 'can do' mathematics, which works to counter the prevalent culture of helplessness and anxiety in the general population when faced with mathematical ideas. The coaches are not required to *know the answer* but rather to develop the learners' ability to explore a problem, and recognize options and actions that might yield an understanding of the mathematical ideas involved and thus lead to an answer.

1.4 Our previous attempt

It is worth stating here that the idea that a non-specialist coach can help support mathematical learners, whilst taking no responsibility for the mathematics, may seem radical if not implausible, though many parents will recognise the phenomenon.

We have previously described an attempt to develop coaches (also called 'Maths Angels', [6]) who did not need to know any more mathematics to support learners' affective development. The Maths Angels were to act as mathematics 'coaches', with little or no mathematical knowledge. Their role was to encourage pupils to talk, encourage a growth mindset [7], encourage collaboration with peers and use of resources such as the internet, and to encourage experimentation. It was emphasised that they were not required to provide 'answers' but rather to support the students in finding their own. Many of the Maths Angels expressed the opinion that they had no vision of how they could help the students. Talking about mathematics appeared to be difficult for them to do and the volunteers insisted that they needed to learn more mathematics themselves in order to support learners. In a subsequent meeting, focussed explicitly on mathematics, just four volunteers attended. During that meeting one of the 'Angels' became so agitated by the mathematics that they were working on that the meeting had to be stopped. Most of the Maths Angels said that they felt that the role we asked of them was very difficult. They felt overwhelmed by feelings of inadequacy and helplessness in the face of the students' difficulties in mathematics. Further meetings seemed inappropriate as what the school needed, they said, was for us to model different ways of working with the students.

This part of our work had reached an impasse; the feelings of anxiety and fear that we knew to be widespread, appeared to be so embedded in the staff with whom we worked in that school that they seemed to be unable to help the students because of their own feelings of anxiety. Thus we recognized that, if the idea was to develop further, we needed more coaching input, and we developed 'the Coaching for Mathematical Resilience' Pilot course.

2 PILOT COURSE

The Coaching for Mathematical Resilience pilot course was designed and delivered by The University of Warwick and The Progression Trust, and was accredited by ASDAN as a development partner. Challenges from the ASDAN Mathematics short course were used as the focus for developing personal mathematical resilience. The Coaching course is designed with 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 their own learners. We discussed the outcomes of the Level 1 pilot in the previous ICERI ([5]). In this paper, we discuss the outcomes of level 2.

The Level 2 pilot course ran from Sep to Nov 2013. The course recruited 10 participants who regularly work with work based apprentices who are required to learn and use mathematics as part of their on-going training. The participants originally became part of the course due to recognition of their own lack of knowledge about how to overcome deep-seated antipathy to mathematics of those who they work with and in most cases in themselves. They had previously successfully completed the Level 1 course.

2.1 Course structure

The Coaching for Mathematical Resilience (CfMR) courses combines two main features: the coaching skills and attitudes, which reflect the principles of developing resilience in learners, and the development of a personal 'can do' approach to mathematical challenges. The course consisted of ten half-day sessions in which coaching and mathematics were interwoven. Challenges from the ASDAN Mathematics short course were used as the focus for coaching activity, together with sample maths papers brought in by participants, as examples of work expected to be done by their trainees. ASDAN's materials are used in the context of CfMR because of a fundamental resonance between the CfMR approach to learning and the 'learning to learn' ASDAN methodology.

2.2 Planned elements

In this section, the key elements planned into the course are described. In our previous paper ([5]), some significant ingredients were described: dual leadership;, the growth zone model; developing a community of practice which was safe and inclusive; increasing awareness of use of mathematics in everyday life and the use of interesting, engaging, challenging mathematical tasks. Additional significant elements relating more specifically to Level 2 are described in the following sub-sections:

2.2.1 Significant ingredient: the Egan skilled helper model

In general, the experience of the learners is of a teacher 'explaining too much' and not fully understanding what the specific difficulty is for the learner (e.g. [8]). In the CfMR model, coaches learned to spend time listening effectively to how the learner is experiencing the difficulty. They then consider what options the learner has available to address the difficulty with as much agency as possible and with minimal help from the mathematics teacher. During the course, the participants learned new skills to work with their learners to avoid premature decisions on what was best to do These new skills are based on Egan's three stages of 'explore', 'options' and 'actions' [9].

2.2.2 Significant ingredient: developing the practice of 'no maths responsibility"

The course works to enable coaches to understand the importance of not providing any mathematics support (even if they can) and leaving the learner with full responsibility for the problem. The CfMR coach does not "do it for them" or even "show them how", but works out with the learner what they know already, what is known by their peers, what can be found out and what needs to be asked of the mathematics teacher or of the wider mathematics community.

2.2.3 Significant ingredient: peer feedback

During the course, there were opportunities to work in groups in which one participant would coach another on a piece of mathematics; peer observers would provide feedback on verbal and non-verbal communication, the use of listening and questioning skills, the Egan triad and the growth model, and the promotion of a growth mindset, inclusion, agency, awareness of resources and community.

2.2.4 Significant ingredient: sharing success

During each session, participants would be expected to share what had happened during the week. Although they were occasionally discouraged, most of the time they would bring stories of work with learners or incidents with members of their family and friends that had reinforced what they were learning on the course.

The Appreciative Inquiry evaluation described in the next section endorsed the approach of recognising and celebrating success.

2.3 Evaluation methodology

Participants on the Coaching for Mathematical Resilience programme were asked to take part in a pre- and post- course questionnaire, and an interview at the end of the Practitioner Level (level 2) course. For the pre- and post- course questionnaire, we used the Mathematical Resilience Scale (MRS), developed from the construct 'mathematical resilience' ([10]). The MRS has three factors: value, struggle and growth.

For the interviews, we used Appreciative Inquiry (AI) methodology ([11]). Appreciative Inquiry uses an asset-based, story-telling approach to explore what is 'right' about learning and circumstances, rather than focusing on weaknesses. This method is used to better understand what strengths exist that can be built on to maximise future impact and enable the positive engagement necessary for achieving success. One to one interviews of around 30 minutes were conducted with each of the ten participants.

3 RESULTS

In this section, we present qualitative evidence of impact on the coaches and learners, and quantitative evidence of impact on the coaches.

3.1 Qualitative evidence of impact on coaches

This section presents evidence from peer coaching and coaching with learners.

3.1.1 Coaching peers

The following extracts from the AI interviews show successful coaching of peers in practice from the point of view of the coach's point of view. Notice the strategies that the coaches use to support the learner without understanding the mathematics.

1. *I let B go through the question and listened to how she would complete the tasks. I used my pen as a pointer. I nodded my head. I asked if she understood what she had to do. I felt amber, comfortable to help B and to support her with the task. B read the question back to me. I was listening, not butting in, not telling her how to do it. I encouraged, not hijacked. I felt confident. I could support B.*
2. *I got excited when I felt confident that what I was supporting F which was helping her, she was getting it. Once I covered up part of the question so she could read it bit by bit. And I got good feedback. Listening, covering up, I let her go at her own pace without her panicking too much. I asked, "What don't you understand?" and "What words do you understand?" "Is there anything you think will help you with this?" She used a piece of paper to cut and fold, a ruler, a calculator. I felt worthwhile and supportive. The look on F's face – a look of relief – she smiled and her face beamed. She said, "I can do this! I understand!"*
3. *P was telling me what she didn't understand. She was asking questions. There were diagrams on the first page. P could not work out what they were for. We had to turn it round to work out the area. I got scissors. I cut out the example. I got excited.*
4. *I was coaching Z. She didn't have a clue. I was shady on the maths myself. I felt this was my turnaround week. Regardless of my lack of mathematics, I could still coach. I felt very positive. I was covering the RAG zone and things like that. Breaking [the task] down. Z was developing more involvement herself. She said ' I know that! I know that!' I thought, if she is involved, she is talking it through, she is understanding, I must be doing something right. I saw Y and another observer nod. I was feeling 'I've done it! I've done what I was here to learn how to do.*

5. *I gave her ideas, was calm, not taking it away from her. It was still her problem. That relieves the pressure on me – I don't need to know the answer. It frees me up to support.*
6. *I was watching what she was doing. I encouraged her to identify the bits she could do – not letting the middle task be a barrier to the rest. I was listening and not talking too much.*
7. *W said she didn't understand the words. I said, 'What if we changed the words to something you are familiar with.' Her face lit up! I didn't understand the word either! When she changed it, it helped me understand the question. It made me realise I don't need to know all the answers. I just need to shut up and let them find their own answers.*

The coaches developed their confidence with peers to support mathematical learning. Their anxieties with the mathematics were still in evidence but they had ways to manage them and it is clear that the support that they were offering led to successful mathematical learning as well as feelings of success within the coaches themselves.

3.1.2 Coaching learners

The data in this section is from the coaches descriptions of working with learners. The data is collated under significant themes, to show the meaning and sense the participants had made of the CfMR course.

1. *Inclusion of the learner in a learning community:*

I was being honest, sharing that I struggled with maths. I told her about this course

I told her I don't know some of the answers because I don't know some of the maths but I will guide her.

We chatted and I told her she wasn't alone in feeling as she did.

Lots of others are in the same place. I'd been in that place before. I asked her to look at Maths from a different view. I asked her about her holidays and, if she's gone abroad, had she learned a bit of the language before going. I told her Maths was a different language and to look at it as a topic that she'd never come across before.

I said that sounded like a good strategy.

We looked at what she'd done and reinforced that she can do things

I got her to show me what she'd done previously (in one to one sessions)

2. *Encouraging progression and growth in smaller steps:*

Would it help if we went through it one bit at a time?

We broke down the question.

When she was getting lost, I suggested she mark the important bits.

praising her for what she'd achieved.

I had to take him back to the beginning; he had jumped too far.

3. *Encouraging agency and articulation:*

I asked her why? What could she do?

Saying, 'Show me what you're stuck on'.

We then agreed she would do three things before she re-sat the paper.

He didn't know what a wick was. I suggested he 'google' it.

I asked, "How do you think we can find out what that means?

I didn't need to do very much. I recognised that and didn't do much.

I asked if there was anywhere in the room that she could get help.

Giving her agency by asking, 'what could you have done?'

Letting her find her own solution.

When he'd completed it, I asked him to pretend I didn't know what he was doing, and asked, "Can you tell me how to do it?"

I asked him about his understanding

4. *Leaving ownership of the problem with the learner:*

Let's see; is there anything you need to clarify; what do you understand? She broke it down herself, she took ownership

I've said, "Let's go back to the beginning, take our time and read the question properly.

I didn't give her the answer. I just asked her the question.

5. *Using awareness of maths in everyday life*:

I put the candles problem in a familiar context in his mum's house.

6. *Awareness of RAG zones and supporting transition from red to amber:*

We took a couple of deep breaths together.

I left the room and followed her out; I suggested we have a coffee and a chat.

Then I sat and talked with her and she became much calmer.

she had got stuck and had gone into red and couldn't move forward

He became panicky (he has autism) he demonstrated clearly he was [in] red. Hot, red, talking slowed. I told him to stop, go back to the beginning, focus on the first bit.

I asked "How do you feel about y?'

I asked her how she felt when she read the question.

7. *And perhaps most importantly:*

I didn't have to use all my coaching skills – sometimes I only need to use one or two.

3.2 Qualitative evidence of impact on learners

The evidence of impact comes from the coaches. The first two extracts show how the learner moves from frustration and self-sabotage to progression and improved attainment:

1. *Normally he gets very frustrated and then throws massive strops … then he did the worksheets and got them all right. He was super chuffed and had to go and show his teachers what he'd done. … how happy he was! He did listen and took on board when I said, "You can do this!" and appeared to feel relaxed.*
2. *The first time she quit after the first few minutes and she scored two-and-a-half percent. I asked her why? What could she do? She understood she needed to attend lessons on the topics she didn't know. We then agreed she would do three things before she re-sat the paper. When she sat the paper again, I encouraged her not to self-sabotage. She scored 49%. She felt confident that she could identify what she was struggling with, which was scale.*

The third and fourth extracts illustrate the impact of calming the learner and helping them feel included:

3. *H. is petrified of maths. Originally I sent her the link and it scared her to bits. She felt stupid. Then I sat and talked with her and she became much calmer. I was being honest, sharing that I struggled with maths. I told her about this course. It made her relax and feel comfortable. I told her I don't know some of the answers because I don't know some of the maths but I will guide her. She was completely calmed. She had been dreading me visiting. Now she was calm and she had done loads. She was making good progress.*
4. *A came across as a 'major can't do it' case. Just doing what we've been taught: let's see; is there anything you need to clarify; what do you understand? She broke it down herself, she took ownership. She worked through the paper. I sat nearby and kept checking 'how do you feel?' After 1 hour, she said it 'wasn't as bad as I thought'. A said: 'I always panic. Every time I meet with you it's not so bad'.*

5. *A lady who was moving on from level 2 to level 3 – she's very competent. I'd given her functional skills to do. I went to see her a couple of weeks ago. She said, "I'm really angry about the maths. I only left school eight years ago and I was good at maths at school. But I can't do this maths." She was stuck on mode, mean, median and range. There was a question about temperatures – but she couldn't remember the meaning of the words. I asked her what she could have done before I came. She said she could have gone on Bite Size (BBC) but as she was feeling so angry she had just put the maths away. I said that sounded like a good strategy. She is 23 or 24 and she had got stuck and had gone into red and couldn't move forward. I didn't give her the answer. I just asked her the question. She offered a solution and she identified she could take responsibility for herself.*

The sixth extract illustrates the coach helping the learner access resources*:*

6. *She said 'I am really struggling with mean, mode, median.' I asked her how she felt when she read the question. She explained how she felt. We broke down the question. She knew but couldn't remember; she was in her amber/red zone. It had been a long time since she did this work before. I felt in my green zone. I had access to information straight away – this is not always possible. There were calculators, internet, resources available. I asked if there was anywhere in the room that she could get help. There were some leaflets on the side. She was pleased to access these. She was happy she could take something away. She went on to pass her maths test*

The seventh extract illustrates the coach helping the learner make use of the internet and make connections with his everyday life that make the problem more accessible:

7. *We were doing something in relation to candles, and how much wax? He could not get his head round it. He didn't know what a wick was. I suggested he 'google' it. I put the candles problem in a familiar context in his mum's house. She has lots of candles at home. Once he connected with his mum's candles, he understood and completed the question. He went on the internet, he used a calculator and the book. I had to take him back to the beginning; he had jumped too far. He became panicky (he has autism) he demonstrated clearly he was [in] red. Hot, red, talking slowed. I told him to stop, go back to the beginning, focus on the first bit. Once he got the first answer, he could work out the price.*

The eighth extract illustrates the coach working alongside a teacher:

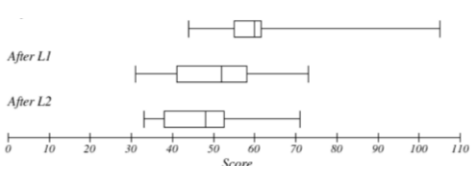
8. *I've had an email from a lecturer from work this week. The e mail says: "….(Learner X) is working well with [coach]; this is a big help as [coach] is really good with her, gets through and connects in a way that I can't. (Learner X) is engaged and on task which means that the rest of the group is also……"*

At this stage in the project, it seems that the predicted impact on learners is beginning to take place, but the focus of the evaluation is on the impact on the coaches,

3.3 Quantitative evidence of impact on coaches

The first box plot (Fig. 1a) shows the overall reduction in the problem (ie increased resilience) as measured at the beginning, after the Level 1 course (L1) and after the Level 2 course (L2) for the 7 participants who completed all 3 questionnaires. It shows is a large improvement during L1, and less change during L2, indicating that the L1 course achieved its goal of developing personal mathematical resilience, but that the process continued for some participants in L2.

This is to be expected, as the focus of the first course was the development of personal mathematical resilience, and partly a feature of the scoring process which has a lower limit of 23, resulting in a clustering effect. Thus Fig. 2b shows the same data as Fig. 2a, but with 23 as the origin to help visualize the clustering effect of the lower limit.



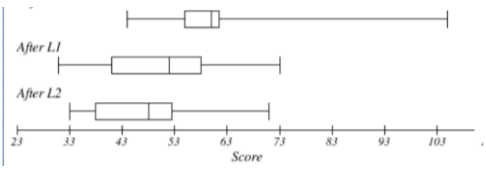


Figure 2: a and b

Overall there is clear indication of quantitative change at a small scale in the direction expected by theory.

4 DISCUSSION AND CONCLUSION

The issue that the construct of Mathematical Resilience was developed to combat is clearly illustrated in this data. There is a strong sense in the data of participants and their learners having to overcome significant initial hurdles to achieve a positive outcome. Feelings of dread, anxiety, anticipation, fear, having to struggle, taking risks or going into danger, permeate the data on the part of the coaches and their learners. The growing sense of achievement, confidence, value and excitement as the participants worked through the course and understood that they could have a different stance to mathematics provides a stark contrast to their initial attitudes. There is a great deal of powerful emotion in the data. There is also evidence that participants have begun successfully to transfer some lessons from the course to their practice outside.

The way that the participants approach their role of coaches brought to mind the image of a swan serenely gliding whilst a lot of work is going on out of sight. Coaches remain outwardly calm, protecting the learner by masking their own anxiety about mathematics and their role as a coach. The success experienced in their role, in terms of the mathematical learning they have enabled in others has enabled their confidence in the CfMR coaching model to grow. They make themselves available to offer sufficient support for the learner, so that the learner can do the learning. They do not need to "know the answer" or even "how it's done" they need to listen, so that difficulties can be articulated, clarified and they can "*reinforce[] that she can do things*". The coach does not "show them how"; they "*giv[e] her agency by asking, 'what could you have done?*' or they "*let[] her find her own solution*". Nevertheless the CfMR coaches have been seen to be a vital resource, as one learner found when he "*jumped too far*", they remind you to take small steps, they ask questions that allow you to know what you do understand, they take deep breaths with you, they stay by your side so that the anxiety and helplessness that never seems far away is safely managed.

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 learners to develop as resilient learners of mathematics. They become able to help those learners to find or develop the resources and skills to overcome their own barriers to learning mathematics and to manage any anxiety that may be engendered. Importantly, when the coach learns not to take any responsibility for the mathematics, but rather to focus on the learning skills and wellbeing of the learner, the learner outcomes are improved.

Final comments from the participants:

- I am thinking of becoming a specialist mathematics tutor. I would never have done that before this course.

- [It has] helped me to support my learners more, to identify the stages. I am more happy to say I don't know the answer, we can look into it together. Before I felt I should know the answer.

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This paper is in part based on an unpublished internal evaluation:

Johnston-Wilder, S. and Garton, E. (2014) 'Coaching for Mathematical Resilience: Practitioner Level Internal Evaluation'. Coventry: The Progression Trust, University of Warwick and Asdan.

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