THE PUPILS' VOICE IN CREATING A MATHEMATICALLY RESILIENT COMMUNITY OF LEARNERS

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We report on our work with one school to develop a mathematically resilient learning community. Pupils acted as Ambassadors to take the ways of working developed together into their mathematics classes and to bring the voice of all the pupils to our meetings. We describe our work within the school and what the pupils told us about the way that they learned mathematics and the way that they felt their learning could be improved. The knowledge we gained was shared with the teachers in the school. Some staff welcomed the ideas; others felt threatened by the notion of working in different ways. We argue that in order for the school to develop into a mathematically resilient learning community a change in thinking is needed by many mathematics teachers.

Key words: Mathematical Resilience, community of learners, pupil voice

INTRODUCTION

In this paper, we report on a single cycle within an ongoing action research project undertaken in one school to facilitate formation of a mathematical learning community, where pupils learned from teachers and from each other, and teachers sought to learn from each other and the pupils. The intention behind the development of this community was to start to work towards increasing the overall attainment of the school's pupils in mathematics examinations taken at age 16. Schools in England are increasingly concerned about their pupils' attainment in mathematics as they can be judged to be 'failing to meet the needs of their pupils' if examination results in mathematics fall below an arbitrary measure. There is also an agenda, driven by government agencies, to increase the number of students studying STEM (science, technology, engineering, and mathematics) subjects at University (Roberts 2002).

THE CONTEXT

We work regularly alongside teachers of mathematics, and recently began an action research project focussed on the notion of mathematical resilience (Johnston-Wilder and Lee, 2010a), the first cycle of which was reported in Johnston-Wilder and Lee (2010b). The first cycle indicated that, in addition to raising mathematical resilience, working in this way also raised attainment of the pupils in a difficult situation.

The cycle of action research presented here took place in an all-girls school in an urban setting in the West Midlands region of England. The school is considered a 'high attaining school', as it is always towards the top in school league tables. However, the managers saw a problem; the overall results in English examinations were always higher than in mathematics. As a result of our previous work, the

Advanced Skills Teacher in maths invited us to work with the mathematics department in order to see whether we could help to narrow this gap. The cycle reported in this paper focused on introducing pupils and selected teachers to strategies for engaging and empowering pupils in learning mathematics, building their understanding of mathematical resilience and using them as conduits for change. We worked with pupils in Year 8 (aged 12-13 years) to change their stance towards learning mathematics and thereby raise their attainment (Dweck 2000).

Our particular role was to enable the pupils to have an informed mathematical voice and to allow that voice to be heard. We were concerned that, when we asked the pupils how their mathematical learning could be improved, most pupils would give stereotypical or naive answers because they had not experienced different ways of learning mathematics. We knew from the theoretical considerations discussed below that, for example, increasing the pupils' ability and opportunity to take part in mathematical discussions, and encouraging them to work collaboratively, would enable them to surmount some of the barriers that learning mathematics often presents and to become more mathematically resilient. The results clearly showed that many of the pupils already knew this.

Typically for an English school, the school had grouped its pupils into classes for mathematics according to their attainment in internal examinations. The teacher of each of these 12 classes or 'sets', chose two girls to take part in the project as 'Ambassadors'. The girls were chosen because of their ability to speak out and take a lead within their own group. We had, in the community of Ambassadors, a mixture of girls in terms of mathematical attainment and mathematical confidence.

THEORETICAL BASIS

The way that we worked in the school was based on the ideas of building mathematical resilience that we have published elsewhere (Johnson-Wilder and Lee, 2010a & 2010b). Our underlying intention was to encourage the teachers to act to make the classroom a more positive place to be and one where barriers to learning mathematics could be overcome. If mathematics is difficult to master, and we see that it often is, then pupils need to develop a positive adaptive stance towards mathematics which will allow them to continue learning despite barriers and difficulties. This positive adaptive stance towards mathematics we have named as ***mathematical resilience*** (Johnston-Wilder and Lee, 2010a). Characteristics of mathematical resilience as we have described it include perseverance when faced with mathematical difficulties, working collaboratively with peers, having the language skills needed to express mathematical understandings and having a growth theory of mathematical learning (Dweck, 2000). Any learning may require resilience at times and can be actively promoted (Newman 2004); however, we argue that pupils particularly require resilience in order to learn mathematics because of various factors that include: the type of teaching often used (Nardi & Steward, 2003; Ofsted,

2008), the nature of mathematics itself (Mason, 1988; Jaworski, 2010) and pervasive beliefs about mathematical ability being 'fixed' (Dweck, 2000, Lee, 2006).

It has been established that emotions have an important role in mathematical thinking generally (McLeod, 1992) and that powerful affective structures are a key factor for effective mathematical learning (Goldin, 2002). We see resilience as an important positive affective construct. Resilience enables pupils to make positive use of their affective domain and is built when teaching takes account of the four aspects of affect: emotions, attitude, beliefs and values (Hannula et al., 2004). We consider that building mathematical resilience offers a way to counter the well-known global affective structures that impede mathematical learning, commonly called "maths anxiety" (Richardson & Suinn, 1972). We see teaching for resilience as facilitating a positive self-belief or self-efficacy in pupils learning mathematics, which have been shown to be influential factors determining the interpretation and appraisal processes constituting their affective responses and emotions (McLeod, 1992).

In this study, we wanted to develop a mathematically resilient community of learners, who were confident enough to recruit other pupils to their way of thinking about effective ways to learn mathematics and to communicate those ways to teachers, thereby including both teachers and pupils in the purpose of improving mathematical learning in the school. Communicative aspects of resilience were particularly important to us in this project. We aimed to promote dialogic interaction, thereby enabling intra-mental ideas to subsequently become inter-mental (Vygotsky, 1981). The strategies that we asked pupils to use arose from work such as Vygotsky (ibid) and Lee (2006), which show that thinking and communicating are intricately intertwined. For example, we invited the pupils to try making mathematical videos and peer teaching. We have previously demonstrated (Lee and Johnston-Wilder, 2010) that video-making is a device that can be used in mathematics departments to increase pupil articulation and autonomy, so we incorporated video-making into this cycle. Peer teaching has also been demonstrated (Lee, 2006) to increase articulation, change pupils' mathematical identities and increase agency.

WHAT WE DID

Our work with the school consisted of three days over half a term spent with the mathematics Ambassadors and additional time emailing and meeting three times with representatives of the teachers in order to plan and review the days. We were joined by a drama teacher from Creative Partnerships (www.creative-partnerships.com), whose role was to inform about and model the use of drama to support mathematical learning. Drama can be seen as enabling dialogic communication and therefore this expert practitioner added to our expertise in building a mathematically resilient community. We used the three days in two distinct ways. Firstly, we introduced the pupils to different ways of learning about mathematics. Secondly, we used the days to enable the pupils to collect and analyse data about the ways that Year 8 pupils in the school felt would be effective in enabling them to learn mathematics.

On the first day, we introduced a questionnaire to examine how pupils felt about the way school encouraged them to learn maths. The questions we asked derived from the work of Dweck (2000) on fixed and incremental theories of learning and the work of Fennema and Sherman (1976) on assessing attitudes to mathematics. We asked the Ambassadors to examine the questionnaire and to suggest changes to make questions more accessible to their peers and any extra questions that may be needed. The original questionnaire was changed in the light of the Ambassador's suggestions and they administered the questionnaire to their mathematics groups. We collated pupils' responses before our next day in school, when we asked the Ambassadors to analyse the response data and identify points that seemed important to them. They reported finding this both challenging and interesting. We also asked Ambassadors to keep journals describing their feelings about, and reactions to, the mathematics they were learning and the way that they were learning it, both in lessons and during our days with them. The Ambassadors were asked to focus in their journals on their own and their peers' feelings and reactions and that their journals were not to critique teachers or record any negative personal reactions other than to learning mathematics. These journals were brought to the second and third day workshops and each pupil drew attention to important points in their journal.

Therefore our data on the way that the mathematics learning community developed in this school consisted of: field notes about our plans for the days and the reasons for revisions of the plans, field notes about our discussions with the teachers in the school and the drama teacher, evaluations from the pupils from the day workshops and notes from our discussions with them, the results from the questionnaire on attitudes to mathematical learning and the Ambassadors' journal entries along with the pupils own analyses of both the questionnaire results and the journal entries.

WHAT WE FOUND OUT

The Questionnaire Results

The Ambassadors distributed the questionnaire to all the pupils in their mathematics classes, collected the completed questionnaires and posted them to us for analysis. Therefore the responses we have represent the views of all the Year 8 girls in 2010. We entered the responses into a spreadsheet, created pie charts and asked the Ambassadors to tell us what the results indicated to them. Thus our analysis of the questionnaire results is informed by the Ambassadors. The results showed that many of the attitudes to learning displayed by the Year 8 girls in this high-achieving school corresponded to those that we would see as resilient. For example, 78% said that they worked hard in mathematics lessons and 80% agreed with the idea that 'I can get smarter at maths if I work hard'. However, 16–20% of the girls were rather more disaffected; it appears that the school will need to work with this cohort and engage them in mathematics in order to raise the school's attainment in mathematics.

We were struck by how resilient in general our respondents appeared to be; 94% reported being sure that they would be able to learn new work in all subjects. This level of confidence dropped by 6% when pupils were asked specifically about mathematics; nevertheless, 88% of the girls were confident in their ability to learn more mathematics. The resilient stance of the majority extended to their willingness to undertake tasks even if they knew that they might not 'do well' at the task; only 17% said that they would not engage with such tasks.

This resilient stance was not so evident when we asked if they "... sometimes would rather get good marks than understand the work." Only 40% agreed and a further 33% were not sure, leaving 27% valuing understanding over good marks. A further 78% said that they preferred getting a good mark to being challenged. Such results may indicate that the majority of pupils in the school are currently motivated by the idea of 'good marks' rather than understanding mathematics. This attitude is further emphasised by the fact that 53% disagreed with the statement "In addition to getting a right answer in maths, it is important to understand why the answer is correct." and 58% did not disagree with the statement "It does not really matter whether you understand a mathematics problem if you can get the right answer."

The answers also showed that for many of the pupils mathematics is 'a chameleon' (Johnston-Wilder and Lee, 2010a). 24% of the girls were not sure that studying mathematics would help them earn a living and 23% thought studying mathematics might be a waste of time; for such girls, mathematics lessons did not help them to distinguish how mathematics appears or is useful in the world outside school.

The data showed that 28% of Year 8 girls enjoy mathematics all the time, 55% some of the time but 17% not at all. It is to be expected that the girls did not all indicate that they enjoyed mathematics all the time; however, that 17% of the girls do not enjoy mathematics at all in the early years of their secondary school careers is rather worrying and, we suggest, underlies the relatively lower attainment in mathematics.

The Workshop Days

The tasks that we used during the workshop days involved learning with ICT using Grid Algebra (Hewitt, no date) and Autograph software, making videos (see Johnston-Wilder and Lee (2010b) for a description of this in another context) to explore where mathematics can be found in the real world, some drama activities as well as data analysis. Our notes from the days, and the pupil's own evaluations, show that all 24 girls enjoyed making the videos: the particular elements that they mentioned about the days were the team work, being able to go outside, using ICT in the form of video recorders, the boost that the activities gave to their confidence and the fact that the activities were more interesting and fun than they had expected. One of the pupils who worked with Grid Algebra wrote in her evaluation of the day: '*something like nth term is usually boring but we understood it'*. After being asked to show the class their work on Grid Algebra, one girl wrote '*I enjoyed making the*

presentation as I learned more about algebra. I would like to do something like this in my lessons as we could perform to each other and learn more'.

Pupils particularly valued finding out some mathematics as part of a group and they enjoyed both working with friends and working with people that they had not worked with before. A pupil wrote: *'we brought our confidence out, writing and really being creative'*. The elements of choice they were offered were also important, as were using visual aids and sharing work. Another pupil wrote: *'all the projects were interesting and my thoughts about maths have really changed'*. The pupils also mentioned enjoying the more active way of learning that they were offered and that they would like to do such activities more often in their mathematics lessons.

The Journals

The pupils gave us permission to take their journals away for analysis. We noticed ideas in the data that informed us about the pupils' learning; we collected like ideas together and reflected on the import of what they were saying. From this we devised 'stable categories' (Cohen, Manion & Morrison, 2009) that reflected the key ideas discussed by the pupils. A draft letter to the teachers was constructed from this information. This letter was discussed with the Ambassadors during the third day workshop and the quotes given below either come directly from the pupils' journals, were recorded during the discussions of the letter or are from the wording of the letter agreed with the Ambassadors.

We discovered that these pupils intuitively knew ideas about effective teaching and learning of mathematics that were supported by research literature. For example, they either knew or had discovered that, in the best lessons, teachers talk less and consequently pupils talk more. Many of the journals mentioned that mathematics teachers talk too much. "*When we are not involved enough we lose focus so we would like less teacher talk, more pupil work and more expectation of effort."*

It is important that pupils feel able to ask their teachers when they do not understand and that the teachers "*explain and help if we are stuck*". Peers are also important to learning; the Ambassadors said that classmates should be allowed to help one another and recognised that pupils learn best when they can support each other and '*have a laugh occasionally'*. Contrary to the questionnaire results, the Ambassadors' descriptions of lessons valued understanding and reported that pupils liked lessons where all are given a chance to understand the essential elements. The timing of the lessons was important; according to the pupils, lessons should be well timed and not involve "*sitting still for too long and being bored*". The pupils are aware that they do not do well in an environment where the work is "*boring and repetitive*".

The journals also made clear that the pupils "*would like teachers to have higher expectations of us*". They wanted more challenge and felt they would be more engaged when challenged. "*We don't mind hard work. We are not afraid to work hard."* They liked teachers to be sufficiently strict in lessons to ensure that pupils

learn, but not so severe that they discourage questions and problems. Pupils stressed that they like teachers who set high expectations and expect them to do well. Pupils enjoy working on difficult questions "*that will help us in the long run*."

These pupils would like more variety in mathematics lessons, less book work, a diversity of tasks and more group work. They do not believe they learn or remember when working solely from books. They like to be active, interacting with other people, giving presentations, working independently and completing projects or extended work. They said such activities boosted their confidence and helped them learn to work independently. They enjoyed it when a pupil prepared and taught part of a lesson; they said it is useful when pupils work at the board for the rest of the class to consider and question. They see value in complex tasks, using a range of skills in a lesson. Similarly, they would like projects and extended work.

> "We would like more interactivity, more games and interesting activities, more practical work and creative tasks, like making and testing helicopters as some did this term. We like more fun activities and we like adventures ... We like maths we can recognise in the real world".

The pupils like to learn using computers and said computers are not just for playing games. They felt that work such as making presentations using ICT helped them to learn and those who had opportunity to use Grid Algebra recognised its value. They also suggested that they should be given optional ICT tasks for homework.

Pupils would like to support each other more; they asked for more group activities, team work and collaborative work. "*For example, one day this term, we did a GCSE problem and had to work as a group. It went well and everyone enjoyed it and began to work as a team.*" Sometimes, teachers could split the class into "*those who can do it and those who can't.*" The pupils pleaded: "*Make sure all pupils understand the topic*". They recognised that they needed to be proficient in using the mathematics register if they were to fully understand and become confident in using mathematics. "*We would like teachers to give us more help on the meaning of words.*"

The working environment was important; the pupils liked the room to be not too hot so that they could concentrate well and they liked interesting wall displays. The ethos of the class was crucial; pupils needed a relaxed environment where they could feel trusted and allowed to talk to one another whilst working. They do not enjoy working in silence: "*we don't like the atmosphere of silence and it makes us feel locked in. We like it when people are talking, getting on with interesting work and able to ask questions with a helpful teacher.*" They also told us that they did not like to be asked if they did not know – it made them feel "*dumb*."

CONCLUSION

We were struck by the extent that the pupils' ideas resonated with research about learning mathematics and our own research about how pupils become more

mathematically resilient. Pupils understood the importance of collaborative learning (Wiliam, 2008; Mercer and Littleton, 2007) and how important it is for the pupils to use the language of mathematics (Vygotsky, 1981; Lee, 2006). They also understood the importance of variety in keeping them motivated and interested.

There was a contradiction in the data concerning the importance of understanding. In the questionnaire, only 27% unequivocally valued understanding over getting good marks, whereas the Ambassadors' journals clearly plead for the teachers to "*Make sure all pupils understand the topic"*. This could be a false dichotomy; it is likely that the pupils appreciate that, when they understand their work, they get good marks in examinations. It seems more likely from the questionnaire results that the dialogue in school values marks over understanding and that the pupils' plea about understanding should be listened to, if attainment in mathematics is to be improved.

The majority of pupils were willing to form a learning community in order to learn more about succeeding in mathematics. Most of them willingly presented their views about what they thought best helped them to learn mathematics. Those few who were less willing told us that they did not expect to be listened to and hence considered the process a waste of time. They became more willing as it became clear that the data they provided was recorded and considered. However, their conviction that teachers would not listen was partly supported. The teachers themselves, who had all been willing participants at the start of the process, became divided along a continuum by the second workshop. There were some who dropped in on the pupil days to see what was going on, discussed ideas with us and invited their pupils to demonstrate new ideas. However, others were deeply suspicious; they came to share lunch with us but were reluctant to talk and did not allow pupils write in their journals during lessons. Other mathematics teachers varied between these two extremes.

Why the divergence of attitudes on behalf of the teachers who had agreed to take part in the project in the first place? We know, from teachers who have discussed the ideas with us, and from the completed journals, that the reluctant teachers have a view of teaching that conforms with the stereotypical teaching described by Nardi and Stewart (2003). Therefore, the changes that were being promulgated may have appeared to deskill these teachers, possibly making them feel incompetent.

The data collected from the Year 8 ambassadors conformed to the way research defines 'effective' teaching: active, reflective, collaborative and grounded in the real world (Askew and Wiliam, 1995). Many of the pupils said firmly that they were not afraid of 'hard work'; they enjoyed being challenged, and working on complex, tractable problems. This view is far from the atomised practice of mathematics teaching prevalent in many schools in England. However, from our data, based in the pupils' experience, we argue that part of enabling the school to develop into a mathematically resilient learning community will be a change in identity (Holland et al.,1998) on the part of some of the mathematics teachers; moving from practices that tend to be repetitive, and focussed on techniques, to working with the pupils to

develop mathematical understanding; moving from teacher as deliverer of knowledge, to pupil as an active, resilient participant in the learning process.

The pupil data clearly confirms our previous research that, if pupils are to become sufficiently mathematically resilient to overcome the barriers presented in learning mathematics, they must be more involved at all stages in the learning process. They must feel that they have the ability, opportunity, time and confidence to work to overcome any obstacles that are presented in learning mathematics. Therefore, they must feel supported by teachers and their fellow pupils, be challenged by the activities used and have time to fully engage in and succeed with their mathematical learning. Their questions must be fully answered and understanding should be valued over everything else. Above all pupils must not be made to feel "dumb".

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