I COULD BE THE BEST MATHEMATICIAN IN THE WORLD… IF I ACTUALLY ENJOYED IT: Part 2

Susan Steward and Elena Nardi

Students often referred to fond memories of occasions when they had enjoyed maths lessons because the format was different or dynamic.

In the previous issue of MT we presented some issues around 'quiet disaffection in the secondary mathematics classroom' [1] and questioned what actually constitutes 'meaningful' engagement in mathematics. We painted a rather gloomy picture of secondary mathematics through the experiences of Y9 students in our research project and how they wanted more:

Noel: ***"I want to enjoy maths, but I can't because it's so boring".***

In this issue we want to suggest how students can be re-engaged with their mathematics so that they feel more positive about their school mathematics experiences. Three main components emerged from our interviews with the students: the nature of 'fun' in the maths classroom, preferred ways of working and the structures that organise students' mathematics learning.

The nature of classroom activities – the notion of 'fun'

When students were asked what sort of things they had enjoyed in their mathematics careers they often used the word 'fun' to describe activities. 'Fun' often meant different things to different students but nearly all students commented that 'fun' activities also helped them remember maths better and reinforced their understanding.

Charlotte: ***We used to play maths games to make you work it out and you used to understand it more because it was fun and you [were] paying more attention.***

Gemma: ***When you enjoy something you remember it, like . . .***

Laura: ***. . . good memories like a holiday.***

The sort of 'fun' activities described would usually be placed within 'using and applying mathematics' either as short activities such as games and puzzles or longer ones such as practical projects or investigations; being part of a group or the class was often a component to these activities. Students often referred to fond memories of occasions when they had enjoyed maths lessons because the format was different or dynamic:

Craig: ***. . . we played this grid game – we all had to stand facing the opposite way from the board, [the teacher] put up a grid, and that was our times table thing . . .***

Noel: ***You need to run and say three threes and you just quickly . . . write in nine.***

Puzzles include an element of competition that can be alienating to some students if done individually – however in groups they allow everyone to compete without being afraid of losing. It appeared that there were often a number of factors that contributed to the enjoyment:

Rosanna: ***. . . we did this project on the computer about a racing car . . . There were three people in each group and it was kind of a competition thing, you had to make the best using all these different maths things.***

In some interviews it was hard to draw students out on the types of activities they enjoyed as they had little or no understanding of investigations or experience of any practical work in mathematics. However one boy, John, in such a class did suggest how maths should be taught differently:

I don't think we should have to do so much work out of the books – more kind of sheets and investigations, and things like that, you know, problems.

From his very limited experience he was clear about how investigations were different and how he

learnt from them:

> ***. . . instead of sitting there working with questions out of the book you have to do it yourself, you have to go and think about what you're going to do . . . you have to plan out and that and then do it. You know, like trial and error.***

Many students liked more practical activities that they could relate to – these were an incentive to some students at risk of being disengaged and de-motivated. In his interview Robin discussed how he would choose to do the minimum work necessary to keep out of trouble if it was 'boring'; however he then described a different type of activity that had been set:

> ***We had to find as many shapes, draw as many shapes as freely as we could that used five cubes . . . and I really like that sort of thing so I did the whole thing and I completed it.***

Students often complained that the work set in maths was difficult to relate to and had no use in their lives. It is interesting to compare the reactions of two students to the same SMILE [2] card on Roman numerals – Darren himself picked this from his book as a task he had really enjoyed whereas Alice could not see the point at all:

> ***. . . that's not maths, that's just translating things. And that doesn't help you with the maths at all, that's just saying I know how to decode Roman things.***

SMILE cards need care when setting because, at the heart of the scheme, there is an individualised approach. There simply cannot be a 'core' of key cards from which teachers pick without considering the student as an individual with different needs, interests and learning styles. Hannah's enthusiasm for a card teaching adding halves, quarters, eighths might not have the same relevance and appeal for another pupil who might not relate to the context:

> ***. . . the musical notes . . . that just seemed really light-hearted. The way they've interpreted it with the musical notes and everything was just a really good way of doing it. Whereas last year, they would have just had a lot of numbers.***

Students also talked about other subjects they enjoyed and why. It seems a waste that their interests in other subjects are not exploited through cross-curricula links and common coursework, particularly with subjects such as art and technology. Many students interviewed said art was their favourite subject because 'everyone has their own style' and 'you can't be wrong in art' – when asked if mathematics could ever be creative they seemed to find the notion ridiculous. Students often talked with pride of work they had done in other subjects and valued the autonomy and trust afforded them; Robin talked about his favourites – technology and art:

> ***They're more fun than maths or science or something like that and English 'cos you get to do things that you want. We get to choose what we draw sometimes in art and in technology everything we do is just really good. . . . we're making a candlestick and we get to choose a design for it so instead of doing a really basic one I'm doing a really hard one so that it's more of a challenge.***

This way of working was certainly not apparent in the observed maths lessons where there were no examples of project work and little student-led learning. In mathematics, students were usually set closed exercises with no choice as to what to do next or how to go about it; as Robin comments:

> ***We get told to try and work out a puzzle or something but it's really easy usually or really difficult and you can't do it at all.***

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Ways of working

Whole class teaching is still the norm in most mathematics classrooms in which the teacher is expected to lead and direct. Pupils are usually set the same task that they work on individually – group work usually amounts to one pupil helping another rather than being mutually dependent for the task to take place. Many students do not find this isolated way of working satisfactory. Individual schemes certainly did not suit all those interviewed, however some students actually favoured placing the resource at the centre of their learning rather than having to rely on the teacher. When asked the difference between other maths schemes and SMILE some students focused on the resources:

Sheena: ***Well you've got the teacher talking . . .***

Carla: ***Which wastes time.***

Sheena: ***And in SMILE you can just read it and get on.***

Darren: ***. . . but when he has to speak a lot and explain stuff . . . it can sometimes get a bit boring.***

Some students in this class had previously found whole-class lessons difficult as they were forced to work too quickly without being allowed the chance to understand:

Yuanna: ***I prefer SMILE because you can work at your own pace and . . .***

When asked if mathematics could ever be creative they seemed to find the notion ridiculous.

Hannah: ***I was [also] in Set 3 last year. I really hated maths and I just could not work at the pace they were going. It was like really fast and some of it I didn't understand and I just couldn't get on with it well. I got moved down onto SMILE and I found it a lot easier and, like Yuanna said, you just sit down and work at your own pace. It's not pressurising you.***

Students in the SMP[3] school also complained that the pace was set by a few boys at the front. It was not that the work was too hard it was just it was too rushed:

Ellie: ***I think time is definitely part of it, what you need to understand it. Because sometimes it just goes through your head . . . and you're rushed into doing it and either [you] get them wrong or it might not stick in your head.***

Steph: ***Sometimes she'll move on to another subject when you're still writing and you never get to finish because she's just moved on.***

Ellie: ***I think she uses the pace of people who are like slightly cleverer than other people in the class, and so people don't necessarily understand it, . . . they get confused and they don't have enough time to answer the questions and maybe get them wrong.***

On the other hand some students liked feeling part of a class, part of a whole. Alice, who hated the individual nature of SMILE, returned to the idea of working together and whole class teaching again and again:

. . . last year [. . .] we just worked altogether. We had . . . the same sheets and we'd work with our friends. And this year we just work by ourselves. I prefer working with friends, like last year. [. . .] you could just turn around and say I don't understand this and things like that, and they would just help you and the teacher would be doing the same things.

When group work did take place students were positive about their experiences of working together.

Between the extremes of an individualised scheme and whole-class teaching lies group work, although few examples of real collaborative learning took place, even when there were opportunities for it:

Mikaela: ***. . . sometimes you look at a card . . . and you think, this card would be so much more fun and better if I could work with somebody else.***

When group work did take place students were positive about their experiences of working together:

Cheryl: ***There was one time when we were sort of working together when we went into the computer room . . ., people did start to try to help each other . . ., like a team I suppose, the first person to get it.***

Some students were very clear about what they meant by groupwork – when Alice was asked about doing surveys as a whole-class activity she described them as a 'group activity' that the whole class did whereas for Sheena when whole class investigations are set which could offer opportunities for group work:

. . . it's like individual, the whole class do it but individual. . . . if we done it altogether [. . .] then that could be easier because there's more of us sort of thinking.

The structures that organise learning

Schools categorise students into ability groups and therefore determine who can and who cannot do maths. Many students think it is unfair to assume they are unable to succeed or that they are not capable of more challenging work. They are prevented from at least trying for higher levels and grades. Noel is in a Y9 class that is labelled 'intermediate' when it was pointed out that he was aiming for intermediate GCSE:

. . . we don't want to do that. That's unfair. . . . on the SATs . . . do we all get the same paper? Even the really high people as well? [because in KS2 SATs] . . . him and Kieran got to take the extra paper because they were so bright. But they don't let anybody else have a go . . . they might be surprised.

There is a real problem in this labelling of pupils, now even at primary level, as many will be prevented from reaching their potential. The challenge facing maths education today is how to increase the number of students taking A-level maths – we are not doing ourselves any favours labelling pupils at an ever-decreasing age. While most schools will allow intermediate GCSE tier candidates to enrol onto A-level courses the messages sent out to these students are clear: namely, that they will find A-level mathematics hard and that they themselves will have to fill the gaps that would have been covered in higher tier courses. Robin wants to be a structural engineer so he knows that he needs mathematics A-level. However:

I don't want to do it at all because it sounds really difficult. But I have to do it to do the job I want. . . . if I don't get the job I want I won't be happy.

Students not only feel that the school has labelled them but also their friends – they can feel 'defined' by their maths set:

Jade: ***. . . and if you're not in a good maths group or a science group, then people automatically think 'she's not very clever'. But they don't know what you're like in English.***

And it also does not help their self-esteem:

Alice: ***I just enjoy being in higher sets because it kind of makes you feel a bit better about yourself.***

Most mathematics departments cannot set in isolation – they are often blocked with other subjects and most year groups cannot be accommodated at the same time. Often sets are very mixed – ability in the bottom set of the top band where students wish they could move down or in the top set of the bottom band where students wish they could move up. A number of students told me that they thought the 'banding was all wrong', especially in the school blocking mathematics with modern foreign languages. Another consequence of this policy was gender imbalance. In both schools that banded the bottom maths set from the top band was girl dominated (eg, 6 boys out of 29) and the top maths set from the bottom band was boy dominated (eg, 4 girls out of 30). Both minority groups did not like it. Schools often ignore the social consequences of setting when they aim for homogeneity. A student's perceived ability in mathematics is not the only factor that determines the mathematical success of that student and it is not always where they learn best or prefer to be:

Juliet: ***I prefer lessons where you're with your form group because you know them; you've been with them since Y8. I find it better to work with your form because you know everybody, you can talk to everybody, you're not uncomfortable with anybody.***

Moving down or up sets can mean that students either do not feel 'stretched' or there are gaps in their knowledge – Hannah has suffered both ways – when she was in a low set she found the work easy:

. . . it did sort of occur to me a couple of times that it was too easy and I thought, well, I know I'm bad at maths but I didn't think I'm this bad and I didn't know what was going on really. I didn't know whether they'd noticed I was bad and they were just seeing if I could do this then move me up to see if I could do that and see what group I was better in.

But when she was moved to a higher set she found that she had massive gaps:

. . . it was quite sort of scary because it was the [top] band . . . which isn't just like the next group – it's a really massive step and I was quite scared because it was really harder than the work we were used to doing. [. . .] Some of the time [the teacher asks] 'can you remember us doing this last year' and [other pupils] go 'oh yes' but I'm just like sitting there going 'no'. [. . .] I feel as if I've missed something that I was about to do before I moved up that could have helped me understand in this group.

There appears to be a particular problem in maths – perhaps because maths is like a set of building blocks that form a foundation for later work, if the foundations are shaky the whole thing tumbles down. Other subjects perhaps deal in more discrete topics.

I'm fine now I've moved up to the [top] band for every lesson. And all the other lessons, except maths, I feel like I should still be in the [top] band.

Many students did not object to setting in mathematics but only if they felt the work they were doing was appropriate for them. There can be problems not only with placing pupils in hierarchical sets but also assuming mathematics itself is hierarchical and individuals' mathematical development is linear. Joe discusses his frustration with the 'building block' analogy when answering whether he thought he should do more difficult work:

Joe: ***. . . it depends by what you mean by more difficult. It's just . . . I have a particularly poor short-term memory . . . so I can't do things like times tables and I never have been able to.***

SJS: ***But the shape and space stuff?***

Joe: ***Yeah, I can easily do that.***

SJS: ***Algebra?***

Joe: ***Yeah, I can do that. But it's easy for you if you think of maths as building blocks, until you've learnt times tables you're not allowed to move on to anything else. So I've been stuck there for ages!***

The teacher can make a difference

It is difficult to assess to what extent students' responses to mathematics are determined by the nature of the subject itself or by their experiences in the classroom. Students who are negative to the subject can usually remember instances or periods

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when they felt more positive to mathematics and about their ability to do it. Many students said the teacher makes a big difference to their enjoyment of any subject and maths in particular:

Jade: ***I have to get on with them because otherwise I just sit there . . .***

Charlotte: ***. . . . you don't concentrate and you don't want to learn. You don't get it [the subject] into your head if you're like moaning about the teacher all the time. . . . you look forward to the lessons if you've got a good teacher.***

Noel: ***The teacher can make it other than 'boring' or 'snore' or . . . whatever words were used [to describe maths]. It could be better than that.***

It is strangely hard to define what pupils think makes a good maths teacher although there will always be a few teachers who have what could be described as 'charisma'. Key attributes for most teachers probably include:

- able and willing to help everyone in the class –

  Jade: ***I was alright with Mr J. . . . he'd explain it all . . . and if I didn't get it he'd repeat it again and he wouldn't say it in a really annoying sort of voice, he'd be just sort of normal.***

- approachable or able to anticipate students' difficulties and approach them –

  Claire: ***I think I never really go up there (to the teacher's desk) because when I go up there everyone can hear me. [. . .] If he comes up to me then I can just talk to him.***

- offering positive feedback and encouraging students –

  Anna: ***Last year, she'd say how pleased she was with us . . . and how pleased that we'd really grasped it so quickly . . . we'd come out feeling we'd have got something positive from our teacher as well.***

A friendly environment helps all students learn better – being with friends and being able to discuss work are very important factors in learning. Students hate having silence imposed on them and do not feel it helps them learn.

Laura: ***I feel it's a lot easier to [ask] my friends, if they explain it, 'cos I'm like more comfortable. . . . that's the thing, I don't like it when teachers make you work in silence.***

This imposed silence can also lead to feelings of isolation – the only one who cannot do the work:

Eloise: ***In my old school . . . if I didn't understand something I would see most of the class were getting their heads down and I'd be like, sitting there. I didn't want to ask – I felt as if I was the only one that didn't understand it.***

Students sometimes feel they have to work together to really understand work. They feel that they themselves benefit from explaining it to others even if this puts them behind:

Eloise: ***I don't mind [explaining] because it's going to help me anyway. And then if I need help then I know that they will give it to me. [. . .] I get it most of the time when the teacher explains it and then when I go over it again with whoever, it kind of does go back into my head and I think, I'll be able to do this. . . It reassures me that I'll be able to do it, if I explain it.***

Seating plans can be useful in ensuring that students mix and that no-one appears isolated but it appears that seating plans cannot force students to work together if they do not like one another or if they work in different ways. They can resent being separated from their friends who actually help their understanding.

We have evidence from the interviews that students can be re-engaged and can feel more positive about their mathematics. Hannah, having hated maths and being scared of it for so long now finally feels she is achieving on her own terms as she is allowed the time and thinking space she needs:

Hannah: ***'Cos since I was just a little kid, my mum used to be really good at maths and she used to try and teach me things at home and I was like, leave me alone, I don't want to know this. I really hated maths so much. And in Middle School it just got worse and worse. Then last year, it just got so bad to the point where I felt like, just like bunking off lessons and hiding up somewhere. And I almost did a few times. Now I just like . . . I like maths now. Some of the reasons 'cos of them two [her friends]. But most of it is because it's a lot easier and lighthearted and I can actually do it.***

SJS: ***Less pressure?***

Hannah: ***Yeah. It's a change that I can do maths. Oh my god, whoa!***

Final remarks

What the students seem to be saying in the interviews is that they want variety both in the resources and activities that are used and in the teaching approach. The resources and activities need to encourage them to be active not passive learners and they want to be able to relate to their mathematics in ways that are relevant to them. Different teaching approaches need to encompass their own different learning styles to include opportunities for individual work, for groups and as a class. There is a real need for this variety as relying on one approach and format will certainly not suit everyone all of the time and perhaps will not suit anyone any of the time.

Individualised schemes are not necessarily 'the answer' – no scheme suits every student and no resource is liked or valued by every student. While resources and ethos are usually determined at departmental level each teacher needs to decide how she or he will use the available resources and make them their own. In the growing climate of conformity in mathematics education there is a need for teacher autonomy and control as it is the teacher in the classroom who best knows the individuals in their care. Rigid schemes of work do not encourage innovation and individualism – teachers need to take risks once in a while and have fun doing so. No resource can stand on its own, it cannot be allowed to determine social interaction within a class or prescribe a particular style of learning.

A balance needs to be found between teacher and resource. Some mathematics educators emphasise the teacher as the focus of every lesson but with 85% (or more) contact ratios this is nigh on impossible; teachers need to have a bank of good resources that they feel happy using in a variety of ways. Many students also appreciate good resources – they can give them a different way in to the ideas and allow re-reading and reflection. Yet students do not want to rely on resources completely, they like being taught as long as it is by a 'good' teacher, they want to be part of a class learning together and not always an individual learning on their own.

It has been argued that in a few years time pupils will arrive in secondary schools with better numerical skills and with more positive images of mathematics gained through their experience of the national numeracy strategy at primary level. Indeed by that time the numeracy proposals will also have been adopted in a number of KS3 classrooms as well. We too hope that students will be less disaffected with mathematics in years to come. However we also hope schools will not adopt the numeracy proposals uncritically as our research shows that blind faith in one resource and in one strategy to encompass all learners is misplaced. If there is no variety in the types of activities undertaken or structures of lessons then the numeracy hour will not be enjoyed or valued by all pupils in the classroom. The numeracy proposals appear to be class-focused or small group focused: is there room in these proposals for individualism? The pupils we interviewed talked about their individual needs and interests – activities they enjoyed, topics they found easy or difficult, preferred ways of learning; they wanted to be individuals. What is perhaps most worrying about the numeracy proposals is the suggestion that it is easier to teach pupils within perceived ability groups. We would argue that if pupils arrive in secondary schools already saying they cannot do maths or they are not clever enough for some topics in maths then they are already potentially disaffected and lost to the subject.

Students need to enjoy maths now; they need to want to engage with it, they need to be told that they are able to do it. We need to ensure that when they finish their mathematical education, even if this is at 16, they can at least feel positive about their experiences of mathematics and their mathematical abilities.

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1 Jerry Oakley: ***RHINOs – Really here in name only***, A research project about the quietly disaffected for The Norwich Area Schools Consortium (NASC), 1999

2 Secondary Mathematics Individualised Learning Experiment (SMILE). All resources published by SMILE Mathematics – contact www.smilemathematics.co.uk

3 Schools' Mathematics Project (SMP 11-16); CUP

Also see: J. Boaler: ***Experiencing school mathematics: teaching styles, sex and setting***, Buckingham: Open University Press, 1997

PUZZLE

In Ken Follett's book, *Code to Zero* (Pan Books, 2001) a couple of characters exchange banter by giving each other a number and challenging the other to say what was special about it. Subscribers may, like me, have been unaware of and interested in exploring the following:

For a 3-digit number, the sum of the first digit, the square of the second and the cube of the third give the first number thought of: eg, $135 = 1 + 32 + 53$

What is the next highest number that follows the pattern? (Answer in Follett's book if necessary!).

Sum the cubes of the digits of a 3-digit number. Repeat the process with the result to get the number first thought of: eg, 136

$13 + 33 + 63 = 244$ and $23 + 43 + 43 = 136$

$29 + 2 \times 2$ is a prime number for every value of x up to 28.

8000 is the sum of 4 consecutive cubes: $8000 = 113 + 123 + 133 + 143$

Finally, because one of the characters lived in a house numbered 16830 she knew that this was the sum of all the consecutive cubes from 1134 to 2133 (I haven't checked this yet!).

Harvey Blair

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