

Case Study 19: Creativity in Mathematics

**Pollock Children's Centre, Glasgow
Borgue Primary School, Dumfries and Galloway
Education Advisory Service, Inverclyde Council**

This series of short case studies explores creativity and problem solving in mathematics with contributions from pre-school and a primary school, and from a local authority describing the approach taken in its secondary schools.

Pollock Children's Centre

To a number of people in society, and in teaching, mathematics is something of a grey area caricatured by many stereotypes of difficulty, bad learning experiences and images of grey predictability. The truth is that mathematics can be fun and highly creative in terms of both learning and teaching particularly in the area of problem solving.

The Pollock Children's Centre is a purpose-built pre-5 establishment in Glasgow catering for children from babyhood through to their final pre-school year. The learning and teaching approach is firmly based in a problem-solving approach. Staff have been trained in facilitating problem-solving activities with young children and the nursery prides itself on building these activities into all aspects of its work. Staff construct what they term 'problem-solvers' to accompany most activities and the children look forward to the thinking and doing that these engender. Irene Macintyre, the head of centre comments:

We want to make maths fun and a natural thing to do. In line with all good pre-five practitioners we ensure that there are plenty of materials appropriate for mathematical experiences surrounding the children in their everyday play. Staff exploit these as part of a planned programme and as opportunities arise in the course of the day. We do base our core programme on a published scheme but a lot of our real mathematics comes from problem solvers and special projects.

Projects can include activities like going to the garden centre to buy bulbs as part of our environmental programme. This would involve the children in choosing the bulbs, counting them and sorting them into bags and handling money when it comes time to pay. Another one involved the supermarket where we took the opportunity to devise a range of interesting problems providing opportunities for talk about price, estimate, quantities, weighing, numbers and money. The supermarket is an excellent way of sharing maths experiences with children since it is so much a part of their everyday experience. The kinds of problem we gave them included,

- Is the biggest coin worth most money?
- How many small bottles of milk can you pour into the large one?
- Can you find large, medium and small tins?
- How many eggs fit into the box?
- What do six large apples weigh?

Interestingly many parents say that they don't like mathematics and were bad at it in school. Clearly we need to alter their perceptions as well as work with the children if we are to succeed in ensuring a positive view of maths on the part of our youngsters. We do a workshop with parents and in that we mention the importance of using

contexts like the supermarket. We outline for them the opportunities they have to teach mathematics and change perceptions of it as an area of interest. When we do maths projects we display them and we have a pocket adjoining the display with a booklet for parents in which we outline how they can work with their children on maths-related topics and problems connected with everyday life. We also try to explain the purpose behind nursery activities like water play and sand in terms of mathematical experiences and what they can do in activities like washing – matching socks, or counting out potatoes for the evening meal. In fact we have a couple of booklets. One is fairly detailed and the other more of a quick reference booklet but both reinforce the workshop and also stand on their own.

I found the workshop to be most helpful for myself to work with my child at home. Most important I realised I do not need to spend lots of money on games to help. Everything was very well explained and gave hands on experience. I enjoyed this and never realised until now that maths can be fun.

Parent evaluation

Central to our philosophy is a commitment to raise children's awareness and appreciation of their environment and this provides a first-class context for mathematical talk and exploration. We did a series of environmental walks with different themes, one of which was a mathematical theme. We were concerned to address shape. We started with a car in the car park and discussed tyres being circles. During the walk we then looked for circles of different sizes, colours and materials – that was one of the problem solvers. We noticed that one road sign was square and we set a problem of finding other signs of a different shape. The children noticed signs with numbers in them and another task became finding other numbers in road signs and discussion of what the number stood for and the context of the sign saying what it did. The children found shapes in fences, paving and shapes in doorways and play areas. They looked at shapes in car headlights, and items of street furniture. Perhaps it is best summed up by the photograph and caption of one child who was accompanied by her mother as a helper.

Mum there is a triangle on the roof of the Pollock Sports Centre' as she noticed the roof shape.

It is vital that we help to inculcate a positive view of mathematics and problem solving as interesting as well as challenging and above all as something which is fun to do.

Irene Macintyre, Head of Pollock Children's Centre

Just as with the mathematics of exploration and fun in the nursery context the same principles of fun in enquiry and problem solving can be found in many primary classrooms.

Borgue Primary School

In Dumfries and Galloway at Borgue Primary, a small rural school of 27 pupils, mathematics is definitely something to be enjoyed and explored.

I like maths the way we do it. Investigations are fun and you just don't get maths as wrong as you used to when you used only the textbook.

This statement by Fiona in P6 encapsulates the pleasure and confidence that children in Barry Litherland's P5–P7 class have in tackling an area of the curriculum many adults, and sadly many children, associate with failure and disinterest. The following extracts from conversations with Barry Litherland,

the headteacher, and some of his pupils illustrate a creative and rewarding approach to mathematics at the primary stages.

I work in a way that tries to eliminate the divide which some seem to place between creativity and raising standards. I actually believe that by promoting creativity you do raise standards. Indeed if you ignore that aspect of things I think you are inhibiting the achievement of high standards. This is one of the starting points for the work we are doing. The other is the belief that a textbook approach can place a false ceiling on achievement. In fact I think that a textbook bound approach may limit what some children can achieve. I am not certain that children actually learn in the established progression which many maths textbooks assume they do.

What I try to do at the moment is to take a creative activity with which the children can identify – one where there is an enthusiasm to learn and from that activity I try to predict the kind of skills that activity will help to develop. I then try to define an agenda and programme for the things which might be learned through that activity. The activity gets underway and I observe the way in which the children are learning. I pick out those aspects of the agenda which interest children or where children need to develop skills and I use these as the teaching agenda. Textbooks tend to come in at the end of the process as a means of monitoring that they have mastered a skill.

For example, we are working on a cube investigation. If you imagine a four by four cube made up of smaller cubes then when you immerse it in paint some cubes will have one face painted, some two, some three, some no paint at all because they are hidden inside the big cube. You ensure the children have understanding of what you want to do so you look at a single cube and show them what happens until they have understanding. Then you build up the investigation with different types of cube. Patterns start to emerge and they try to anticipate what is going to happen. The language used is the language of shape and enquiry. Formulae begin to emerge and in time they are able to predict what will happen with a range of cube types. By choosing an investigation like that the motivation is there, they want to find out and they are thinking. I already have an idea of where this is going to go and by planning the agenda I can fit different aspects of development to different children, which is important in a composite class. I can then teach to that agenda both in the context of the problem and also independently from the problem but relating things to it. We can progress it to an advanced level where they are working out complex formulae to solve related problems. I find that children at P5 and P6 levels are tackling problems at a level beyond normal expected levels – but confidently and with success.

My assessment strategy which relates to 5–14 allows me to monitor progress and to identify gaps. Sometimes I have a difficulty relating some of the work to 5–14 but the framework provides the basic

yardstick of progress. Where gaps appear these can be addressed by developing the investigation, engaging in direct teaching, utilising textbooks or by developing new but related investigations.

One of the heartening things is that the words 'fun' and 'maths' are always linked. Virtually every child will say this. Dialogue is absolutely crucial – teacher/child and child/child. However this approach builds in the freedom to have this essential dialogue. Sometimes we have gone into more open-ended investigations which involve me and the children making genuine discoveries – we are learning together as a kind of learning team. It is a wonderful exchange. My structure of knowledge is more sophisticated than theirs, my organisation is better – what I am trying to do is to close that gap between my structuring of knowledge and theirs through dialogue.

The learning process is important. Some might say that what I do would be slower than other methods for establishing basic skills and mathematical confidence. I don't think that although I worried about it at one time. I just have to look at the results of the children achieving further than objectives defined in 5–14. Of course being in a small school with smaller classes helps.

The early stages classes do focus on number skills and building confidence with number, which helps greatly for the way I work with them in the middle and upper stages. I would say that they develop good number sense early on – that ability to deal with number and to apply number.

We developed a town trail in Kirkcudbright where we went out to look at the built environment but we didn't take any measuring equipment with us. We used non-standard measures like paces and hand-spans to convert these to standard measurements. My agenda there was not only about measure but also about providing a real context for understanding and needing averages.

Choice is a word often bandied about at present with regard to learning and teaching. Choice has to be more than whether we do English now and maths later. It has to involve giving children choice of strategies and approaches. By giving that kind of choice the teacher will learn about what children really understand.

If we are doing a crazy context like how many Mars bars to Mars or how many Smarties to get the length of a room children need to be able to adopt a variety of strategies. Even when they are comfortable with multiplication they can choose repeated addition, often using different multiples. My job as a teacher is to observe that, see where they are comfortable and share ideas with them to help them to move on.

Work is often done in groups and you have to be sure that everyone is

taking part and contributing. You have to ask yourself if any are slipping through or if they are not engaged because the task is too difficult. I have changed my planning system so that once I have identified the context for learning and picked out the agenda I now differentiate the tasks better according to my knowledge of each child. I do this not by fixing drop-off points for children but by being clearer about the agenda. For example with the cube investigation some children were fine up to the point of identifying patterns, some children worked through the patterns and others got to the stage of expressing a formula relating to the number of cubes on an edge. They shared in the investigations but there was no expectation they would all reach the same learning point. I provide opportunities to monitor and assess, teach and then repeat the cycle to maintain progress at individual and class levels.

New children joining the school do take a while to adjust. The freedom to choose a strategy often phases them. However one of the most enjoyable aspects of that adjustment is seeing them change their attitude to a subject which previously they often did not like.

I have used both video and audio systems to monitor my work with children to assess the quality of the dialogue, who is contributing, whether or not I am speaking too much – that sort of thing. I think we as teachers need to do that to ensure that we are at times varying our teaching style and approaches to meet different pupil learning styles.

One thing we did do in association with the area primary manager was to set up a 'Problem of the Month'. The problem was tackled by schools and the answers sent back to him and then displayed at education offices. The first one was so open-ended I found comments from teachers wanting an answer before the children had a go – it seems not everybody is happy about not knowing the answer to a problem before tackling it!

Children often make presentations or booklets on the tasks they have been tackling. In addition they make smaller-scale presentations for wall display on say number analysis or aspects of a particular investigation. Jotters are used for working out and I do treat these as first-draft jottings with a second drafts being asked of some items. A lot of material is presented on the walls, displayed and discussed.

We did plan a maths festival for this year but foot and mouth put paid to it. We had hoped that all the local primary schools would be involved. The intention was to make maths more interesting and fun. The event, which will run next session was to have been based in the local secondary. We intended to have two workshops which travelled round the schools. One was to have been a maths storyteller doing work with young children and another one with a technology focus for older children. Schools would also organise their own activities and we would share items. The maths town trail produced by my school would be

available. The last day of the week was to be a focus day in the secondary school with workshops and activities involving problem-solving teams for older primary pupils. We had organised computer-assisted activities including floor-turtle work and the museum service had been involved and they gave us historical maps of the area and we were designing activities to go with them. Sadly it didn't happen but next year's planning is well underway as a result.

Flexibility is important. You have to leave room to capitalise on developments which are going well although there is always this guilt trip about whether or not the curriculum balance is being compromised. Once we had a theatre company in the school for three days. I was happy to think it would dominate the activities over that period and be a great experience for the children – which it was. However by interval on the first day I was worrying about what they might be missing. This was wrong, instead I should have been thinking about what they were gaining and have had a much better plan thought out for making up for lost ground and capitalising on the gains which we achieved My planning takes much better account of the need for flexibility now.

Barry Litherland, Headteacher, Borgue Primary

And what do the pupils say? – P5–P7

We do work with Smarties. How many Smarties to get to Pluto. You have to lay the colours in the same order. We then try to predict what colour the 100th Smartie will be or what number the 50th red one will be and things like that. Of course you don't actually go to Pluto – you work out a formula for the answers. It's great fun – and you get to eat the sweets!

We discovered formulas for working out the painted cube problems – it was like finding a secret to lost treasure!

On the town trail we had to work out the height of buildings – it was easy really – you just worked out the size of one brick and then 'timesed' the number of bricks long ways and vertically. In another one we did it in groups of five bricks.

We also made a booklet with all the activities for the town trail – things like finding shapes in buildings, measuring distances and working out heights. We put the booklet into the tourist people for visitors to use.

There was a competition we did about car racing – like David Coulthard – it was a computer thing and you had to work out fuel loads and tyre pressures and things like that. This was against a lot of schools and we came third. Good for a girls team, eh!

We don't really need calculators. I prefer to think numbers. I think I understand them.

If I can't work out a fraction I simply draw it and I can work it out from there.

It's no use just using LOGO to make the turtle move – you soon get bored with that. We use it for angles and rotational symmetry and things like that.

I am convinced I am getting better results and better attitudes – far better than I would with any other approach.

Inverclyde Council

In the secondary sector work in Inverclyde on the introduction of accelerated learning techniques and problem solving echoes a number of the features of the work in Borgue. Margaret Robertson, Educational Advisor for Inverclyde Council observed:

As part of our teaching and learning policy directions in 1996 we determined that one avenue we wanted to explore was thinking skills. We looked at the published programme Cognitive Accelerated Science Education (CASE) produced by Kings College in London. The evidence from south of the border was of positive impact on exam results but also that the thinking skills and strategies developed were transferable since students not only improved in science but also in other areas of the curriculum. The reception for CASE in our secondary schools was good and so when accelerated thinking was built into a mathematics context in the Thinking Maths Programme (CAME) we felt that it was worth exploring too.

The programme is geared to accelerating children's thinking particularly in moving them on from concrete operational to formal operational thinking. The focus of CAME which is targeted at S1 and S2 is problem solving, which is very much part of the mathematics curriculum. Each of the Thinking Maths lessons involves the process of pupils moving towards learning mathematics concepts in small groups, individually or as a whole class through discussion of ideas and strategies. We felt the comprehensive CAME format of planned and thoroughly resourced activities, including teacher notes for each activity, backed up with effective training would give an added dimension to mathematics learning and teaching in our schools.

Problem solving is integral to our course and so fitting in a well thought out scheme like this was not a problem. We tended to do problem solving as a block before, rather than in the way we do it now in terms of alternate weeks with a mental strategies period. We have mixed ability classes but the children work in ability groups and we maintain these for the problem-solving work.

Jill Morrison, APT Mathematics, Notre Dame High School

We engaged a CAME trainer to coach staff and he identified that the biggest problem for teachers is actually standing back and letting the children come up with answers. In his second session he worked in an actual second-year classroom situation and I think this reassured any doubters amongst staff about the worth of the approaches. The training made use of videos of the trainer making observation on his own teaching and this pointed clearly at the need for participants to examine their own teaching practice. We have two maths teachers in each school who attend the training and they have the responsibility for training colleagues in their departments. Soon teachers began to identify issues like curtailing problem-solving sessions too early because solutions hadn't been reached and interfering overmuch in the process of pupils' working out collaborative answers. Teachers will shortly be having sessions where the trainer will visit them and make evaluations of their practice in action.

The training emphasises the importance of developing skilled questioning techniques and this dimension needs to be better focused in pre-service training. You need to have the perspectives to ask the right level of question and the patience to wait for answers to be formulated, particularly as a group response from pupils. I think the more you work with these methods you find it permeating other aspects of your teaching and it encourages you to remember that teaching is not lecturing. You should be asking questions and encouraging responses and not telling pupils what it is they should know and then go on to the next sixteen examples.

Mark Barrie, PT Mathematics, Port Glasgow High School

We have done a lot of work since 1997 on improving basic numeracy with a particular focus on improving mental calculation and this together with good general mathematics work provided a sound basis for the problem-solving developments. In mathematics there has been less concern about taking anything out of the course to accommodate the thinking work because problem solving has a fixed priority in the mathematics course. In science however there was initially some concern from staff regarding removal of course elements to accommodate the thinking work.

When I introduced the approach to the department we shared concerns that the approach might have implications for time available for other aspects of the coursework. The reality is that it simply takes up the time used in other approaches to problem solving and so there is little if any loss of curriculum time for other aspects.

Mark Barrie, PT Mathematics, Port Glasgow High School

The children are getting much more from the activities in the programme because of the quality of the activities and the back up for their teachers. The teachers are getting more and for some it is the first time they have had real collaborative learning happening in groups as opposed to children simply sitting in groups. It is also plain that positive attitudes to mathematics are being more actively fostered particularly with children who were not enthusiastic for the subject. Where departments are enthusiastic the motivation for pupils and staff is very high.

You have to keep an eye open so that the same children do not do all the work and maybe some work on strategies and organisational skills to make the groups better at self-management would be a helpful thing at the start, since the temptation for the group to constantly seek reassurance from the teacher is high.

Jill Morrison, APT Notre Dame High School

We are at the early stages of CAME as we have only been working it for a session but already we are seeing areas for future work. For example in P7 there is scope for this sort of activity and it would be a very useful link in terms of continuity of approach between the primary and secondary sectors. We are piloting a positive/creative thinking programme in one of our primaries and initial feedback from that is good. There may well be mileage in us combining these approaches.

What CAME is doing is encouraging teachers to look at their practice as much as it is giving pupils exposure to high quality teaching and learning resources and enhanced mathematical experiences. We have run other courses and inputs on thinking skills and accelerated learning over the past few years and also seminars on this and others such as gender issues in learning, mind-mapping, Brain Gym, music and learning and others. We have been trying to engender a climate where reflection on practice can begin to have a real impact on pupils. I think that teachers themselves are beginning to see these developments not as something extra to add on to the curriculum but rather as integral elements of ongoing work.

The main impact on teaching has been the way it has made us step back and

look at how we teach particularly with regard to how much direction we give in our lessons. The training has made us appreciate the need to get more from the pupils. It encourages enthusiasm in the children. When they pick up on the nature of the task and get involved the motivation filters round the classroom.

Jill Morrison, APT Notre Dame High School

In coming up with creative ideas for teaching problem solving the CASE material is putting creativity back into the problem-solving process for both pupils and teachers. There was time not so long ago when some teachers taught problem solving as a formula thing with problems being capable of solution simply by applying the correct formula. Now we are looking at problem solving as being an exploration of the process with often more than one way to answer the problem and with solutions being drawn from pupils rather than provided by teachers. Teachers are now giving greater priority to facilitating the problem-solving process in classroom and also giving pupils not only the opportunity to engage in such work but also the time to think and to do it properly.

It is early to say what the long-term impact will be but it certainly is generating enthusiasm. There is a lot of interaction in the groups as they tackle the tasks and there needs to be good constructive questioning and clarification as part of the teaching strategy. It is enjoyable for both teachers and pupils and it has certainly generated motivation.

Mark Barrie, PT Mathematics, Port Glasgow High School

It is interesting at the training sessions for CASE to hear teachers so openly sharing their classroom practice, talking about what they need to change and how things can be improved. This did not happen so much a few years ago. In addition this kind of talk and sharing is promoting an extended team perception which goes beyond the boundary of each individual school. Similarly within departmental meetings there has been an increase in the focus of learning and teaching practices which can only be of overall benefit to professional practice and learning.

We were talking about this year's Standard Grade Credit paper which threw a lot of pupils. It wasn't that they couldn't do it but just that the way it asked the questions was different from last year. Children should not be thrown by that sort of situation and what we should be investing in nationally, is the development of the thinking skills and positive attitudes which will see a child cope with what he/she comes up against not only in exams but in life generally.

Margaret Robertson, Educational Adviser, Inverclyde Council

In the area of problem solving in mathematics there is much happening in schools that is both creative and innovative. A number of features that point towards an actively creative learning and teaching situation are highlighted by these pre-5, primary and secondary exemplars.

- Pupils have planned opportunities to develop and apply their creativity.
- Pupils are expected to develop and apply higher-order skills.
- A challenging range of tasks is available to pupils to develop and consolidate their creative abilities.
- Pupils are enthusiastic and value their learning opportunities.
- Pupils are motivated to persevere with challenging tasks.
- Pupils explore a range of ideas, consider their quality and apply solutions accordingly.
- A climate of enthusiasm and pleasure in learning is fostered and valued.
- Teaching approaches are positive and non-threatening.

- Pupils are confident and secure in classroom management and organisation.
- Class display is effective and values the input of all involved.
- Time is prioritised for creative working.
- Open-ended problems are set for pupils.
- Pupils and staff receive regular feedback.
- Schemes of work and programmes of study show planned continuity and progression in the skills associated with creativity.
- Management and staff support the principles involved.
- Management commits resources to ensure implementation of strategies.
- Staff provide effective models of practice.