CREATIVITY AND MATHEMATICS: USING LEARNING JOURNALS
Alf Coles and Gemma Banfield report on the power of journals to support learning

The 'I' in this article is Alf's voice, later in the writing when we consider some pupil's work we have interspersed a commentary in italics, indicating Gemma's voice. This commentary links what we present about the work of three pupils to the wider class.

In 2010, I was privileged to be invited to work in Gemma's classroom in Colerne Church of England Primary School, where the headteacher wanted to develop creative approaches to the teaching of mathematics. We were successful in applying to the National Centre for Excellence in Teaching Mathematics to set up a project as a Mathematics Knowledge Network. The project was the start of what is still an on-going collaboration between the charity "5x5x5=creativity" (5x5x5) and the University of Bristol, where I work. In this article we report on one aspect of the project - the use we made of learning journals for pupils.

5x5x5 place artists in schools, in collaboration with a cultural centre, to set up projects with students and staff, for more information see www.5x5x5=creativity.org.uk for more details. The inspiration for 5x5x5 comes from the work of the Reggio Emilia early-years settings in Italy (Rinaldi, 2006). 5x5x5 has adopted the following principles from the work of these pre-schools:

- children are seen as innate and creative knowledge builders, explorers and co-constructors of their learning
- educators and artists are enablers and companions in the children's learning within a culture of listening
- learning is focused on the process of the children's explorations, not the end product
- documenting children's learning journeys is our method for evaluating and reflecting upon the children's thinking and learning
- developing a creative learning community of teachers, artists, co-workers in cultural centres, parents and children
- involving family and community in life-long learning (5x5x5, 2011)

Learning here is linked to exploration, process, journey, listening and community. My own background, as a teacher and researcher, has its roots in the work of Gattegno who, in an echo of the first principle, writes of the 'powers of children' (1971, p.16). Gattegno based his pedagogy on exploiting these powers, one of these powers is 'stressing and ignoring', which he sees as the essential aspect of the process of abstraction. In other words, all of us engage in abstract thought whenever we consider two examples and ask, 'what is the same and what is different?', a phrase used by Laurinda Brown.

In conversation with the director of 5x5x5, Penny Hay, we conceived of my work with the primary school in terms of a 5x5x5 project, that is, I would be an artist/mathematician. In the first instance, the school wanted to set up a project with their two Year 3/4 classes, one of which was Gemma's. The headteacher wanted to develop pupils' creativity with a particular focus on the capacity for logical and systematic thinking. Penny and I met with staff to talk through some of the processes involved in a 5x5x5 project. I then met with Gemma and the other Year 3/4 teacher to discuss a range of possible starting points which led to us deciding on a problem from the publication 'An Addendum to Cockroft' (Brown & Waddingham, 1982) involving placing books on a shelf. This task starts off with the problem:

If I have 3 identical blue books and 2 identical red books, how many different ways can I arrange them on my shelf?

We agreed I would start both classes off with this task, supported by the class teachers and a teaching assistant.

My background is in teaching secondary mathematics. In my own classroom I developed ways of working with 11 year olds, and older, such that students became familiar with the process of asking questions, making conjectures, testing out their own and each others' ideas and trying to prove statements. At the start of this project I had little idea how relevant these ways of working would be with much younger children.

Again, in discussion with Gemma and the other Year 3/4 teacher, we agreed that I would offer pupils a purpose for the project of them becoming a mathematician. In the context of this work being linked to 5x5x5, we wanted to develop pupil creativity within mathematics. We took creativity to mean:
In the first session that we gave journals out to pupils I showed them this example of what I had done. The invitation to the classes was to tell the story of their own work and learning on the two tasks we had done together. All the work pupils had done up to this point had been on paper. We made available scissors and glue. We suggested they cut out sections they wanted but emphasized that we wanted them to think about how to be organized in doing this, and also that the point was partly to help them make progress on any questions they had left unanswered from the tasks.

We had planned one session on the journals, but the pupils seemed so engaged by the activity of creating collages of their work that we continued into a second session, which ended up being the last one with these classes. We offer below three examples of what pupils did in their journals, and discuss evidence that, as a way of reflecting on their work, using the journals provoked new learning.

Evidence of learning through a the use of a journal

The following images are of different Year 3 pupils’ work, from their learning journals. The prior attainment of these pupils relative to the rest of their class, and national expectations, was broadly high in Case 1, middle in Case 2, and low in Case 3. These three examples also display the range of different ways in which the journals functioned to support pupils’ own thinking and learning.

Case 1

The pupil writing at the top of page 8, is: “4 squer shapes” and “5 squer shapes”, I interpret this as meaning: “4 square shape” and “5 square shape” which was the language used in the lessons on the Pick’s Theorem project. ‘E’ refers to the number of dots on the edge of a shape and ‘I’ the number inside. Many pupils noticed that they seemed to get the same sets of values for E and I for shapes of the same area.

The pupil, cut out and arranged her shapes in a new way compared to what she had done before, that is, the shapes were drawn more randomly on her paper as part of the Pick’s Theorem project hence, in part, perhaps why each shape was cut out separately. In other words, in her original work she had not been organized as she is here and had looked at shapes with different areas rather than considering separately ones with area 4 and area 5.

She also draws in the learning journal, for the first time in her work on this project, tables of results. It is possible to see that the tables of results are...
drawn directly in the journal and not cut out from paper. Having begun a table of results, it can also be observed that she extends the table beyond the results that she obtained, in order to make a prediction. For example, on the left hand page, with 4 square shapes, all her examples have either 0, 1 or 2 dots inside; but she has extended her table to make predictions for $E$ when $I = 3$, 4 and 5. The latter two being impossible shapes in fact, since $E$ needs to be at least 3 to make a shape.

There is evidence on this page, therefore, that returning to the Pick's Theorem project with the learning journal has supported this pupil in demonstrating mathematical thinking that is significantly higher level than she demonstrated in her original work, now making a table of results and a prediction that she had not done before. I find it intriguing to muse on whether this is simply a function of having more time on the project. My hunch is that the journal was significant in allowing the pupil to approach her own work anew in some way, not constrained by how she had tackled it up to that point. She would have seen examples of other pupils making tables of results, and we discussed some as a whole group; the journal seemed to allow her the opportunity to incorporate this thinking into what she had done. It is only my own conjecture, but I wonder if, without physically re-organising the shapes into ones with the same area in the way she did, she would have distilled out such a table of results from her work.

Gemma:

An opportunity to revisit learning allowed the children to reorganise their thinking based on what they had found out. Some found it challenging to start a problem in a systematic way. They chose a random starting point. So returning to a problem and having time to look through their workings was valuable. These children often chose to completely reorganise their work. In many cases this led to the children spotting patterns and solutions for the first time.

Case 2

The next example from a learning journal is also taken from the Pick's Theorem task. The shapes this pupil arranged are a mix of area 3 and 4. The table of results is for area 4. I interpret the writing at the top of page 9 to be: “Shape Project” and at the bottom to be: “The patterns” and assume this is an unfinished sentence, I emphasized wanting pupils to write down any patterns they noticed.

For this pupil, although the table of results is drawn on the learning journal as with Case 1, he had shown evidence in his previous work on the project of having completed a similar table, but for 5 square shapes.

It is perhaps just possible to see in the table that there has been rubbing out. During the lessons on the journals, the pupil approached
me asking me to check this table. I remembered this pupil had completed a table successfully for his area 5 shapes, so I was expecting this table to correspond to the shapes on the page above. Initially I could see no connection. The first line, which you may just be able to make out, had $E = 10$ and $I = 10$. I asked the pupil where he had got his numbers from for this table and pointed out his shape where $E = 10$ and $I = 0$. He returned to his seat and continued working, rubbed out some figures and re-entered values in his table. He came back to me, but still his numbers did not correspond to the shapes on his page. It was on the fourth occasion of this pupil coming to check his work with me, and my reporting that it did not seem to fit his shapes, that he wrote the values above, that do now all match a shape he had drawn.

If I had been asked to assess this pupil’s mathematical thinking at the end of the Pick’s Theorem project, I would have been convinced that he understood how to create a table of his results. Yet here was evidence that this pupil needed to re-enter the problem of doing this. I am reminded of a quotation from John Holt that I have lived with as a teacher for many years:

*All of us must cross the line between ignorance and insight many times before we truly understand. Not only must we cross the line many times, but in the words of the old spiritual, nobody else can cross it for us, we must cross it by ourselves. Being shoved or dragged across does no good.* (Holt, 1990, p.160)

In case 1, the learning journal seemed to support an extension of mathematical thinking, in this instance the journal seems to function more to revisit and reinforce a previous awareness – a re-crossing of a line perhaps.

**Gemma:**

Revisiting work using the journals led to a deepened understanding of the learning that had taken place. Some children needed to revisit the same learning a number of times before they fully understood what they had found out.

**Case 3**

The third and final example of the use of a learning journal is from the initial red and blue book, or ‘combinations’ task. I offered the standard notation $\binom{n}{r}$ to stand for the number of ways of arranging 5 books in total, 2 of which are red. After working as a class on this starting challenge, pupils then chose their own problems to explore - initially sticking to 5 books in total; for example, finding the number of combinations for $\binom{5}{1}$ i.e., 5 books, 1 red and so, 4 blue, or the number of combinations for $\binom{5}{3}$ i.e., 5 books, 3 red and so, 2 blue.

In the image below, the pupil text at the top I read as: “I know that $\binom{5}{2}$ has only 10 answers”.

The text from the bottom is less clear. My transcription of what he wrote is:

“T’s conjecture $\binom{n}{1}$ = 1 I knew $\binom{n}{1}$ would equal 1 because there is no other colour”.

I interpret this as:

“T’s conjecture $\binom{n}{1}$ = 1 I knew $\binom{n}{1}$ would equal 1 because there is no other colour”.

The pupil who created this page is underachieving in mathematics and literacy against age expectations. There is evidence here of him making a ‘conjecture’, using algebra and offering reasoning to justify his ideas. In his work in the first lessons on this project he had recognized that if there were 5 books and all of them were red, i.e., $\binom{5}{5}$, then there will be only one possible way of arranging them. In this project, I was aware of wanting to offer algebra as a mechanism for expressing any generalities pupils noticed.
CREATIVITY AND MATHEMATICS: USING LEARNING JOURNALS

In the lesson when T made his observation about 5 books and 5 reds, I asked the class to predict the number of combinations with 6 books, all of them red, 7 books all red, 10 books, etc, and offered the \( n \) notation as a way of capturing the awareness that there will be one combination no matter how many books, if they are all red.

What I find striking in the image above is the way pupil T shows evidence of beginning to consider issues of proof and justification. At the top of the page he writes: “I know that \( \binom{5}{2} \) has only 10 answers” - and I interpret the arrow as indicating that he sees as a justification of this statement, the fact that he has written the 10 solutions out.

At the bottom of the page, the pupil cuts out his conjecture from work he had done on paper i.e., that \( \binom{n}{n} = 1 \) but then as at the top, adds a justification. He adds, written directly on the journal page, that he “knows” his conjecture “because there is no other colour”.

As with Case 1, I see evidence here of the use of the learning journal supporting the pupil in demonstrating significantly higher levels of mathematical thinking than he displayed in his original work on the task. Again, as with Case 1, I cannot help myself conjecturing that longer time on the project would not necessarily have provoked such a shift in his recorded thinking. I imagine further time would have seen him continue to explore different combinations and patterns. By revisiting his own conjecture in the learning journal, and with the offer to all pupils to try and write out and explain their thinking, this pupil is able to capture something of his own reasoning that he had not been able to record at the time.

I find it intriguing that the pupil in Case 3 was the lowest attaining of the three and yet the one who arguably had been the most mathematical. I am left to wonder at the extent to which his difficulties in mathematics lie in problems with literacy, and whether these difficulties can act to mask the quality of thinking he is clearly able to demonstrate.

Discussion

When the staff involved in the project and I came to reflect, ourselves, on the ten sessions and their impact, one of the things we were most struck by was the power of these journals in supporting pupils to revisit and take on their work in a manner that seemed to provoke new learning and awarenesses. Gemma and the other Year 3/4 teacher continued the use of the journals with their classes for the remainder of the year.

I have been at pains not to use the word reflection up to this point in the article in relation to what the pupils were doing. It is perhaps now relatively common place for pupils to be invited to traffic-light their own confidence levels, or fill out self-assessment sheets about their feelings on what they can do/understand. I have personally always found it hard to engage pupils in as meaningful a way as I would like with such processes. In contrast, the use pupils made of the learning journals was alive with interest, engagement and, as I hope to have shown above, learning.

It is not an easy task to try and distill out what was significant in the use we made of the journals in terms of provoking the positive response from pupils. No doubt, if pupils had not been engaged with the tasks in the first place, there would have been little interest to document them, and I am aware we have been relatively silent on the role of the teacher in sustaining such initial engagement – but that is a whole different story.

There did seem to be something appealing to pupils about being given an attractive blank sketch-book and I tried to make my modeling of the use of the journal as aesthetic as I could. There was space for creativity in terms of how pupils chose to set out their journals and many of them seemed to take great care in doing this. The activity of choosing what of their past work to include in documenting their learning forced pupils to consider what was the same, or different, across what they had done, i.e., the activity provoked abstract thinking - in Gattegno’s sense - and it seems to me possible that it provoked abstractions about their work that pupils may not have considered if simply given more time on the tasks in the first place.
CREATIVITY AND MATHEMATICS: USING LEARNING JOURNALS

Gemma:

The journals provided a chance for the children to choose how to present their learning. This meant it was meaningful to them. The journals gave the children complete ownership of their learning. The fact that there was no ‘wrong’ way of using the journals and presenting their learning meant that the children, particularly the lower attaining, felt quite liberated. Some children weren’t happy with their initial workings. They were disappointed with the way they had laid out their work and were unable to see any links or patterns. The use of the journal provided a new enthusiasm. Being given a second chance to revisit a problem allowed these children to sort out their thinking.

There seems to me to be tentative evidence therefore, from this project, that it can be powerful to invite an activity of looking back on past work after a short time gap. This may allow a re-entry into the problem unencumbered by the approaches taken at first and may support either a re-working of a past awareness, or an extension of past thinking. Another factor, perhaps, is the use of a different medium for this reflective work, compared to the one of the original production, i.e., where a distinction can be easily made between what was done before and what was added.

Gemma:

Starting a problem for some children is a little daunting. So knowing that there are opportunities to return to previous work gives them some security. They don’t need to get the answer right first time! The children learnt the importance of looking back at what they had found and using what they had found to ask new questions. This prompted new learning and a deepened understanding.

The work in this school acted as a pilot for a wider project, currently in three schools during 2011-12 and from 2012-13 in five schools, that is being funded generously by the Rayne Foundation. I hope to report again from further outcomes of this work.

Alf Coles works at the University of Bristol, and Gemma Banfield teaches at Colerne Church of England Primary School

References


References for: Equations with different technology: different tools, different views - page 14.

References


