Designing a revision lesson in geometry using the Causal Connectivity Framework

How can we nature creative thinking at Key Stage 3 level?

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Introduction

Cultivating pupils' creative thinking is high on the current educational agenda around the world. The Australian curriculum, for example, has identified critical and creative thinking as one of seven general capabilities for the foundation stage, right through to Year 10. Singapore, a leading achiever in PISA (the Programme for International Student Assessment) (OECD, 2015), emphasised creative thinking and innovation during the ability-based aspiration drive phase of its education programme between 1997 and 2011. In the UK, the Durham Commission on Creativity and Education has recently reemphasised the importance of creativity for youngsters and has been seeking definitions, good practice and methods for measurement. In science area, the Thinking, Doing, Talking Science project has tried to test at primary level the impact of creative thinking on knowledge attainment (EEF, 2018). Although the one programme, called NRICH, has proposed creative teaching in maths through problem-solving (Piggott, 2011), there are few examples in this subject area offering examples for pursuing creativity in the classroom. In this article, we will use the Causal Connectivity Framework (see Fig 1) (Dawson & Wang, 2019), as a guide for lesson design to scaffold understanding and logical thinking in Maths within creative thinking.

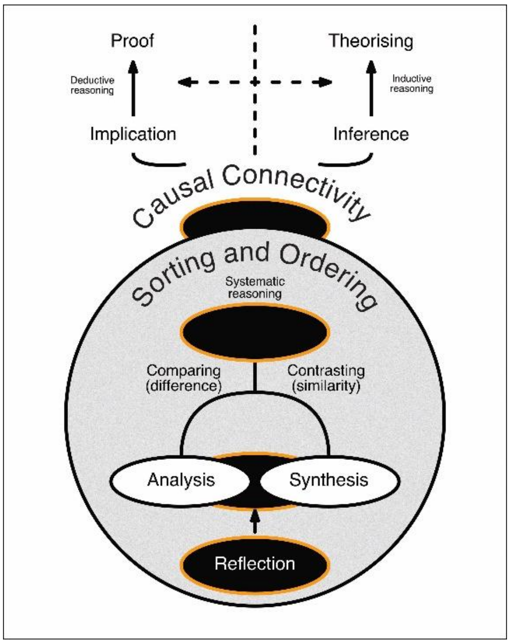

Figure 1 Causal Connectivity Framework (Dawson & Wang, 2019)

Maths has been identified as one of the least creative subjects in the curriculum (Newton, 2012). One form of creative thinking in maths is 'divergent thinking', which means to encourage students to

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explore multiple solutions to a problem, developing their abilities in flexibility, fluency and originality (Acar, Burnett, & Cabra, 2017). On the other hand, Prof Douglas Newton (personal communication) provided a constructive framework for the meaning of creative thinking as having two essential components: being novel or new (at least to the thinker) *and* appropriate or relevant. In this article, we approach creative thinking from three perspectives:

(1) *Expectation*: an underlying belief that all students are capable of making logical/causal connections (irrespective of how simple or complex these are)

(2) *Culture*: all students are capable of expressing themselves given the correct opportunities to do so, and we promote these opportunities and value students' responses.

(3) *Reflection*: If a series of tasks are causally linked (via careful planning), reflection on these tasks will reveal the causal connections.

with the underlying belief that creativity does not need to be and cannot be taught, simply nurtured, and that 'creativity' is the ability to make connections between 'experiences' which brings about new perspectives and new understanding. Within a maths context this process (driven by analysis and synthesis) naturally develops mathematical conceptualisation.

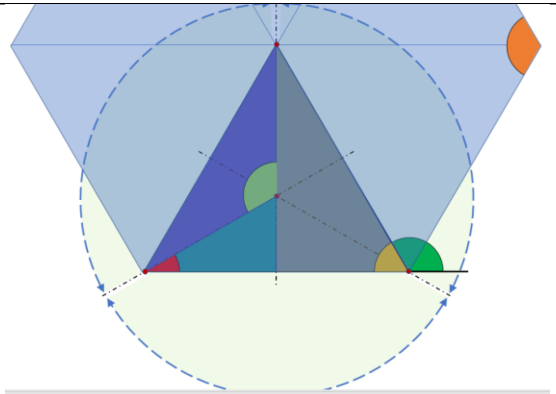
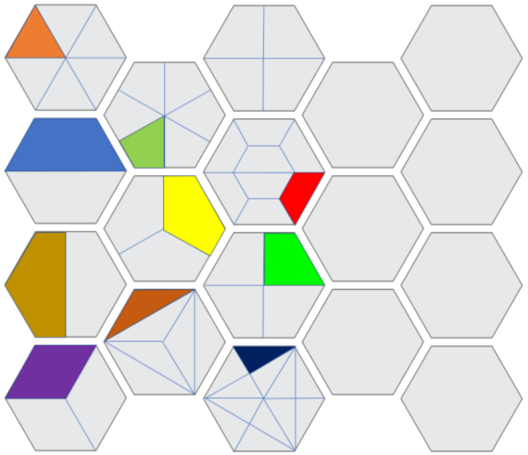
We will now provide a sample lesson[3] on how to help pupils develop and demonstrate creativity as part of their usual disciplinary learning.

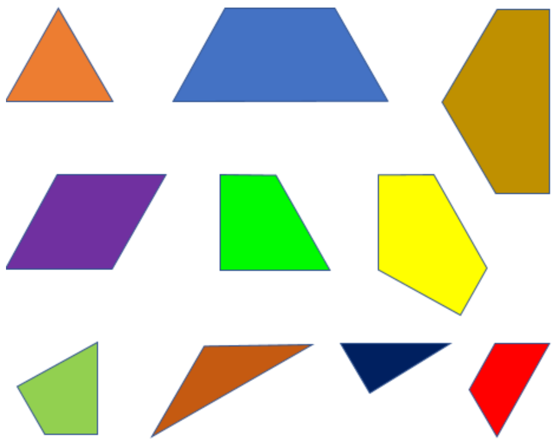
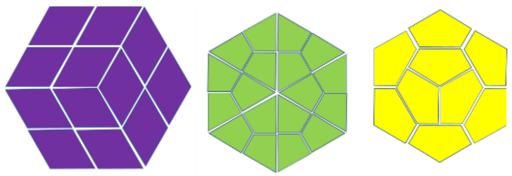
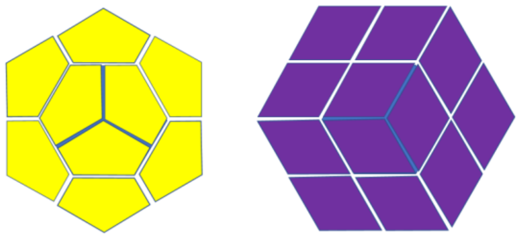
Example lesson

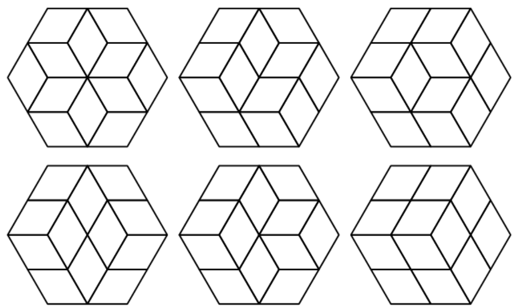
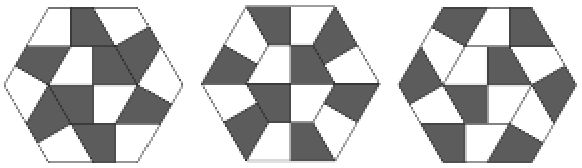
Watson, Jones, and Pratt (2013) listed spatial and geometrical reasoning as one of the seven key ideas in teaching maths. Within this area they specified important concepts such as lines of symmetry, symmetry and transformations; and 2D shapes and their properties.

We have deliberately chosen a revision-type lesson to demonstrate how creative thinking can be nurtured and encouraged through open-ended tasks with a focus on the subject content listed above.

[3] The resources discussed in this are designed by the first author.

Tasks	Task illustration	Subject content knowledge from the Key Stage 3 curriculum (Department for Education, 2013, p. 8)	Reasoning mathematically (Department for Education (2013, p. 4)	Causal connectivity framework
What could you tell me about the properties of an equilateral triangle? So a regular hexagon can be split into six equilateral triangles… or simply… just six equal and identical pieces…		To 'derive and illustrate properties of triangles… using appropriate language and technologies' *Lines of/Rotational symmetry, internal/external angles, types of triangles, similarity, polygonal decomposition…etc.*		Phase 1: Relevance
What other ways can you find to split a regular hexagon into equal pieces? Note how lines of symmetry help uncover the answers…		To 'describe […] using conventional terms and notations: points, lines, parallel lines, perpendicular lines, right angles, regular polygons, and other polygons that are reflectively and rotationally symmetric'.		Phase 2: Analysis and Synthesis

Two of the shapes shown are similar – which ones are they? **What is the ratio of these similar shapes to one another in terms of their area, length of side and interior angles?**		To ‘use scale factors, scale diagrams and maps’.	‘Extend and formalise their knowledge of ratio and proportion in working with measures and geometry’.	
Some of these shapes are very interesting as you can actually build larger and larger hexagons with them… Let’s try to find these shapes…		To ‘construct similar shapes by enlargement, with and without coordinate grids’.	‘Make and test conjectures about patterns and relationship’.	Phase 3: Sorting and Ordering
Assuming that the initial pentagon shape and the initial rhombus shape are cut from the same initial hexagon… what is the ratio of the areas of these two larger hexagons?		To ‘use scale factors, scale diagrams and maps’.	‘Extend and formalise their knowledge of ratio and proportion in working with measures and geometry’.	Phase 2: Analysis and Synthesis

If we use the purple rhombus shape, how many different constructions can you have to make the larger hexagon?		To ‘construct similar shapes by enlargement, with and without coordinate grids’.	‘Make and test conjectures about patterns and relationship’.	Phase 3: Sorting and Ordering
Danni says “I have created a right-angled trapezium by quartering a regular hexagon. Therefore each piece has the value of ¼.” Megan takes a look at the pieces and says “They could be treated as a regular hexagon.” **Use the pieces you have been given to demonstrate that Megan is *<u>also</u>* correct.**		To ‘interpret mathematical relationships both algebraically and geometrically’.	‘Begin to reason deductively in geometry, number and algebra, including using geometrical constructions’.	Phase 4: Causal Connectivity
Using these given shapes, how many are required to build the next largest hexagon…?				Phase 5: Proof or Theorising

Teacher's feedback

This lesson was delivered by the first author to a Year 7 mixed-ability class[4] in North West England, with students who had already learned the relevant concepts necessary to access the tasks.

"It is important to note the distinction between planning and delivery. The planned lesson is 'complete' in the sense that it has a clear focus on content and procedure, however, delivering as is will NOT promote creative thinking. Creative thinking can only be nurtured by understanding how the planned learning sequence can be broken down into mini tasks, and providing space within and between these tasks for the students to ***reflect*** on what exactly they are doing, thinking and reasoning, and how the tasks relate to each other and develop a '*narrative',* by which I mean a through-line of logical development. My role as a 'teacher' is to facilitate these reflective spaces and encourage students to formulate explanations for themselves. I do NOT explain things, that is the role of the student."

Concluding remarks

We intend to raise awareness among education practitioners on how to combine creative thinking with Maths lessons, designing a lesson that inspires educational fun not only for the learners, but also for teachers themselves. However, to do so, we need resources that can facilitate creativity in Maths lessons, and matching lesson designs. Thus, as we have argued, it is of strategic value for educational practitioners to reflect on what might constitute creative thinking for key ideas in maths.

[4] The class is mixed-ability setting with 9 students.

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