'CREATIVE MATHEMATICS' - REAL OR RHETORIC?

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In this paper, we examine notions of 'creative' that might apply to mathematics and to mathematical activity. Our motivation to do so has been our discussion of the meanings of 'creative' which seem to be applied or implied in Upitis, Phillips and Higginson (1997). Our general approach is philosophical, drawing on literature which considers creativity in the arts, in mathematics and in educational settings. We question the tendency of some promoters of mathematics to justify mathematics by annexing it to the arts, and examine whether different kinds of criteria for creativity apply to mathematics.

What's the point of learning mathematics? It is not uncommon for people to say that mathematics is difficult, and that much of what they learnt at school has not been of much *use* to them. We might reply that mathematics is not supposed to be simply useful (if at all). Mathematics, we commonly say, is a subject that at the very least is a source of *fascination*. Sometimes we go further and say that it provides *aesthetic* experience. It is not exceptional either to find claims that mathematics is even a *fine art* alongside paintings, sculpture, literature and music.

Yet, surely, mathematics ought to be able to stand up for itself. This is not to say that it is above the need for justification, but that its rationale should not depend upon resemblance to other areas of the curriculum, since this unnecessarily shifts, rather than solves, the problem. One persistent notion which has been used to bring the arts and mathematics uncomfortably close together is *creativity*.

'Creative' is an example of what philosophers have called 'hooray' words whose meanings are typically imprecise, yet all are heavily value-loaded. They have considerable *rhetorical* force in assertions: to suggest that an educational policy or a subject promotes 'creativity' or is 'creative' is usually sufficient to commend it.

During the 1960s and 1970s, philosophers of education made several attempts to analyse the concept 'creative', and several chapters and articles on the topic of creativity appeared in the literature of the theory of education (Dearden, 1968; Elliott, 1971; White, 1972; Wilson, 1977). Favoured aims in education ebb and flow in their prominence, yet the attraction of 'creativity' in education has by no means vanished. The recent proposals for *Curriculum 2000* - the revision of the school mathematics curriculum in England and Wales - include the following passage:

> As a subject in its own right, mathematics presents frequent opportunities for *creativity*, and can stimulate moments of pleasure and wonder when a problem is solved for the first time, or a more elegant solution to a problem is discovered, or when hidden connections suddenly become manifest.[1] (p. 36 our emphasis)

Although creativity arguably has its home in the fine arts, amongst those analyses

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[1] The acknowledgement, in this passage, that both creativity and discovery apply to mathematics is notable. Often creativity is invoked in order to draw out a contrast with discovery.

referred to earlier, at least one writer has explicitly linked creativity and mathematics. Dearden, for example, in his classic *The Philosophy of Primary Education* wrote:

> Creative work is both plausible and extremely valuable in mathematics ...wherever new theories can be put forward, new proofs advanced, fresh hypotheses formulated or old knowledge reviewed, there is room for creative work. (pp.146-7)

Nevertheless, Dearden's main analysis is in terms of creativity within the arts. Does this then mean that creativity in mathematics is a special kind of creativity, or that mathematics may be conceived as an art form? Dearden does not tackle this question. He does however make certain distinctions, suggesting that there is a sense in which creativity is synonymous with 'crude self expression'; another sense in which it means 'original'; yet another where 'creative' is an abbreviation for 'aesthetic creativity'.

Underlying Dearden's first case (creativity as crude self-expression) is the view that the emotions are somehow 'corked up', and creativity is the process of releasing tension caused by this suppression. This can take on a variety of forms, such as fashioning a beautiful garden or engaging in the arts. The more symbolic expression of grief within the rituals of funerals in various cultures also captures this sense of creativity. But even if mathematics were on occasions a vehicle for such a release, it is less than self-evident that this is one of those aspects in which it has a *distinctive* contribution to make to the curriculum, as the rationale from *Curriculum 2000* (cited above) seems to claims.

Mathematics educators have certainly come to value pupils' own methods of *calculation* when these bear the marks of inventiveness,[2] and it is at this point that we begin to encounter Dearden's notion of creative as 'originality'. Thus, a pupil's 'invented' method of calculation is often prized because of its originality, even though it may not be the most the efficient method possible.

But these two senses are, for Dearden, contrasted with the notion of 'aesthetic creativity' which he argues need not be 'pleasurable self-feeling nor necessarily original'. His point here is that what counts as aesthetic 'can be determined only by reference to the aesthetic object produced', it can only be judged within the criteria appropriate to a given form, and that such a judgement is to a large extent determined by authorities and 'critics' whose arbitration on such matters is based on extensive knowledge of art.[3]

Notwithstanding Dearden's remarks about the place of creativity within *mathematics*, we need to take seriously the point made above that creativity has traditionally had its home in the *arts*. Elliott (1971) has argued that 'the myth of divine creation' runs deep in our traditional idea of 'creative' and for this reason it is the artist - one who literally *makes* something - who is truly creative. Thus, Elliott and Dearden are in agreement that

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[2] Plunkett (1979), an influential classic, is one of the first in a long line.

[3] In a current best seller the author and publisher Michael Schmidt (1998) stresses the importance of the publisher in establishing what poetry is to be. He writes: 'we were the first readers of almost every poem that travelled beyond the charmed circle of a writer's intimates. We said what would go in and in what order, we said change this, drop that (or we *silently* changed or dropped), we abridged and expanded. We assembled anthologies. We decided when a writer should go public, how long a book should live, how widely it should circulate'. (p. 6)

originality and creativity are conceptually linked. Elliott goes on to argue that notions of creativity which lie outside the arts constitute *a new concept of creativity*, one that is concerned with imaginative thinking - the discovery of novel solutions and problem - solving rather that the 'making' of something. This is a useful distinction provided we are clear about what will count as novel or original; this issue will be discussed later.

A rather different issue, however, arises if we try to assimilate mathematics to the fine arts by supposing that the same version of 'creative' applies to both. Mathematicians and writers on mathematics have from time to time tried to argue that mathematics shares common features with painting, sculpture, literature (in particular poetry) or music. One of the supposed links between the artist and mathematician which is often made is via the notion of creativity. A detailed anthology of such claims can be found in Moritz (1914). For example:

> I like to look at mathematics almost more as an art than as a science; for the activity of the mathematician, constantly *creating* as he is, guided though not controlled by the external world of the senses, bears a resemblance, not fanciful I believe but real, to the activity of an artist, of a painter let us say. (Bocher in Moritz, 1914, p.182, our emphasis)

This is certainly true of certain exceptional scientists who have: "... quite radically re-structured our world, which is the world as we conceive - and even perceive - it." (Elliott, 1971, p.144) The same seems to be true of some mathematicians.

Surely *all* good mathematicians must display *imagination*. But to invoke the imagination is perfectly apt in mathematical contexts. Indeed, the concept of imagination is part of what Elliott refers to as the 'new' concept of creative, one which does not entail the making of something, but depends upon the producing of novel ideas and problem-solving. On the other hand this new concept does not sit well with art. He writes:

> *The danger is that by assimilating art to science, we shall misconstrue the nature of art* ... If what counts as a problem has no reference to what the artist experienced as a problem, any and every element in the work can be regarded as a solution of a problem ... this may lead us to analyse artistic creation in a manner which distorts our understanding of it. (Elliott, 1971, p. 148, our emphasis)

The concept of creativity only provides a link between the mathematician and artist if we understand creativity in certain special ways. The version of the concept 'creative', as usually applied to artists, applies only to a few outstanding mathematicians. In its transformed version, where this involves providing novel solutions to problems, it applies to all mathematicians but not necessarily to all artists. The two versions of the concept arguably accentuate, rather than remove, the difference between the mathematician and artist.

WHO OR WHAT IS CREATIVE?

We must distinguish creativity *in* mathematics from creativity in the teaching of mathematics. Notwithstanding the title - *Creative Mathematics* - of Upitis, Phillips and Higginson (1997), part of what is revealed in the book is good *teaching* – the use of certain enterprising resources and the making of some illuminating links within mathematics. We concede that the rhetorical force of 'creative' is relatively harmless here. However, a different plunge is taken when we discuss mathematics by analogy with, say, music. Upitis, for example, draws strong parallels between the stages of learning mathematics and those of music. Just as pupils compose tunes and then attempt to notate these, she suggests that the pupils at work in mathematics are doing the same thing. For example, a pupil makes a tessellating design from tiles and then proceeds to invent a way of recording it. Clearly, the pupils taught and observed *do* invent particularly interesting and effective symbolic representation of their patterns, from which others could recover the pattern made (pp. 42-43). Moreover, these pupils, as a result, also no doubt appreciate the power of symbols of the kind used in mathematics in a similar way to those pupils who invented their own 'numerals' for Martin Hughes' 'tins game' (Hughes, 1986, pp. 64-72). Inventing notation does not exhaust what we want to mean by creative mathematics. Yet it surely entails creative *teaching*, because it leads to a certain kind of illumination on behalf of the pupils.

The parallels between music making and mathematical activity are not sufficiently convincing and break down under analysis. The work of many fine musicians consists of improvisation which is not designed to be written down. It is communicated in the performance. It is fleeting and often has its value in this respect since it is a form *par excellence* of self-expression.

Another linking of mathematics with the arts is to be found in the familiar view that:

> As educators, we would like children to learn about spelling and rules of grammar by becoming writers; we would like children to learn about music theory and performance by being composers; we would like children to learn about arithmetic and concepts of mathematics by becoming mathematicians - *makers* of mathematics. (Upitis et al., 1997, p. 36, our emphasis)

But to suggest that children are 'making'[4] mathematics is to invoke creativity in Elliott's traditional sense, and is thus a radical claim. Pupils can, of course, make patterns from concrete objects, but the question is whether they are thereby making mathematics even if they symbolise such patterns.

Pattern is central to mathematics. Indeed, for some mathematicians, the subject simply is 'the classification and study of all possible patterns' (Sawyer, 1955, p. 12). But does the mathematician somehow 'work out' pattern just as aestheticians claim that artists do? To answer this, we need to distinguish between 'working out' in the sense of *originating* a pattern from scratch, as it were, and 'working out' in the sense of discovering a pattern amongst chaos, or perhaps identifying and describing an already existing pattern. In *Creative Mathematics*, Higginson endorses this distinction when he remarks that:

> Human beings are pattern-*seeking* and pattern-*creating* creatures. Tessellations and tiling patterns have a long and a culturally rich history. They can be seen as *visual poetry*. (p. 50, our emphasis).

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[4] It is interesting to note that for many years it has been customary to show how mathematics education largely involves a kind of 'doing' mathematical thinking rather than mathematical thought - here we have a shift to mathematics as a kind of 'making'. The French word verb *faire* of course does not make (no punning intended) such a distinction.

But can tessellations helpfully be assimilated to poetry in this way? Or is this mere rhetoric? Whilst it would be quite reasonable to suppose that a poet or a painter, sculptor and composer works out a pattern from scratch, it is far from obvious that a mathematician does so. Yet the mathematician G. H. Hardy has written that:

> A mathematician, like a painter or a poet, is a *maker* of patterns. If his patterns are more permanent than theirs, it is because they are made with ideas (Hardy, 1967, pp. 84-85, our emphasis)

We have conceded that *some* distinguished mathematicians may create - in the sense of 'make'- mathematics and also that mathematics might be regarded as the 'classification' and 'study' of pattern. But Hardy asserts that a mathematician does indeed make such patterns, the chief criterion for the success of which is beauty. Fully-fledged mathematicians do construct axiomatic systems, but this does not imply that they can claim to have thereby constructed either the theory or the patterns which may be deduced from those systems. Karl Popper (1972) has written that:

> The series of natural numbers which we construct creates prime numbers - which we *discover* - and these in turn create problems of which we never dreamt. (p 138).

The sequence of prime numbers certainly presents a plethora of complex problems, and it may *seem* as though both the primes *and* the problems have been thereby created rather than discovered. The same may be said of pattern. Even if we admit that mathematics is created - or perhaps more neutrally that it is constructed - there is no need to suppose that the particular patterns which are later discovered are those which mathematicians had ever dreamt of. [5]

It may be too narrow a view to suggest that it is only professional mathematicians who can make mathematics. Perhaps the pupil seldom produces mathematics which is original to the wider mathematics community, but might they not nevertheless produce patterns or conjectures that are 'original to them'? This issue is supported by Higginson when he reflects upon a 'paper jewels' project. He writes:

> Both ideas were original in that neither Rena nor Doug had experienced their ideas before. But neither original idea was unique. Other people make paper jewellery, and did before Rena began crafting her own. Other people have tessellated quadrilaterals as well, long before Doug discovered his pattern. Original ideas - or non-derivative ideas - can be powerful even if not unique. (Upitis et al., 1997, p. 91)

This point was raised by White (1972) who considers the case of a boy who discovers his own rule from some given data rather than being given the rule by teacher. White's strongest argument is levelled against those who suggest that such 'original' response, on behalf of the pupil, are valuable because the processes involved are comparable with those of a mathematician. He writes:

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[5] Popper's reference to what is 'dreamt' of is rather pertinent here. Even Poincaré could claim that mathematical solutions were 'created' at a subconscious level. Paul McCartney, too, claimed to have literally dreamt up his composition 'Yesterday' and was not at all sure whether it was rightfully his at first. But the specific patterns that arise from a mathematical system, surely, do not even enter the mind

> In the case of the boy, his teacher has structured the situation in such a way, by e.g. providing clues to guide the child close to the desired goal, that the child takes it for granted that there is a rule to be discovered, that the teacher knows what it is, and that by following the teacher's direction he can come to find out what it is as well. None of these conditions hold for the creative mathematician, who therefore could not have made his discovery in the same way as the child. (p 137)

CONCLUSION

Creativity is not exclusive to the fine arts. It also has some clear applications to mathematics, science and perhaps elsewhere (perhaps everywhere) in education. However, different notions of 'creative' exist. To see mathematics as embodying imaginative thinking, and problem-solving is to see one apt version of 'creative' at work in our discipline, one which is clearly well worth striving for. However, to attempt to apply the version more characteristic or the arts – to say that mathematics is a kind of *making* - where the scope of 'making' extends beyond an extra-mathematical artefact - is misleading and is thus mere rhetoric. Between these extremes, however, lies a grey area. Beyond the cases of problem-solving, we may want to call more commonplace responses 'creative', simply because they make their first public appearance through the deliberations of each pupil (or perhaps because they are the of outcome of creative *teaching*). On the validity of this particular application of 'creative' one may feel somewhat torn. Is it mere rhetoric to apply the hooray word 'creativity' in such contexts, or is there something real here which we do want to uphold in the name of 'creative'?

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