Art And Mathematics: A View From Art

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Introduction and outline

Speaking from the point of view of an art educator (in this instance) I see an expansion of attempts to link art and mathematics and am increasingly concerned with the answers to two questions:

- Is it Art?
- Is it Mathematics?

Often to the mathematics specialist anything that makes an attractive display is artistic. Similarly to the art specialist anything with geometrical order and shape is mathematical.

But, as Barnes (1993) asked "It may be cross-curricular but is it really art?" and gave the criteria that cross-curricular links must:

1 Benefit the particular subject area in question

Does he mean subject areas?

2 Develop and respect the core concerns of the subject

Subjects?

3 Give coherence to an otherwise fragmented curriculum.

And I still would want to ask, as well, "is it really mathematics?"

In this paper I want to examine why mathematics seems to want to link with art in the present climate when subjects are individually specified under the National Curriculum and any cross-curricular links are expressed in terms of elements, i.e. dimensions, skills and themes (1990). Then I want to look at some of the published educational material making these links and see what it sets out to do in terms of mathematics and art. Finally I would tentatively suggest a model which would have validity in both Art and Mathematics in the new curriculum.

The aim is not to look at links between Fine Art and mathematics which are well established, particularly during the Renaissance and Modernism, as this has been well documented elsewhere (for example in the journal Leonardo, Holt (1971) and Blij (1985)) but to consider whether it is valid to make these links for the benefit of pupils' art education and/ or mathematics education.

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Why make the links?

One can perhaps argue that art, if it is required under the National Curriculum to develop numeracy as a cross-curricular skill (and I would define numeracy in the widest terms to include a general mathematical competence and fluency), would want to make links with mathematics. But why would mathematics, secure in its position as a core subject, want to make links with art?

A close observation of the development of the mathematics curriculum over the last few years leads me to suggest the following reasons:

1. A changing view of mathematics

An understanding of the nature of mathematics has moved from the Platonic 'content' view of mathematics as a fixed body of knowledge and the child as a vessel (as Shuard (1985) said "a rather leaky vessel") needing to be filled, to a process view where the child is responsible for constructing their own Mathematics (Kilpatrick 1987). This implies that knowledge is actively constructed by the cognizing subject, not passively received from the environment and that coming to know is an adaptive process that organizes one's experiential world, it does not discover an independent, pre-existing world outside the mind of the knower. More recent work in sociology has also acknowledged the importance of the cultural context in which mathematics is constructed and its influence on the content of the mathematics (for example Gerdes 1988 and Chevallard 1990).

Mathematics has also been redefined both by the Cockroft Report (DES 1982) and HMI (1985) as a 'powerful means of communication'.

2. The need for mathematical 'investigation'

This changing view of mathematics has led to a new focus on the processes of mathematics and in particular the value of 'investigations', a concept first brought to the attention of teachers by the Cockroft Report *(op cit).* This is one of the reasons why there was so much concern about the possible merging of the Attainment Target 'Using and Applying Mathematics' in the revised National Curriculum and a conviction that this aspect should be reported on as a separate facet of pupils' ability in mathematics.

Pupils now have a statutory requirement to 'use and apply mathematics in practical tasks, in real-life problems and within mathematics itself' in all Key Stages (SCAA 1994) and teachers are therefore increasingly looking for appropriate and mathematically rich contexts in which mathematics can be used to describe and explain the world. Art is one such context which is rich in pattern and other relevant concepts.

3. A broader mathematics curriculum

The National Curriculum has also placed a statutory obligation on teachers who in the past may have concentrated exclusively on teaching the understanding and computation skills associated with number to address a broader and more balanced curriculum in mathematics.

An obvious link with art is in the area of Shape and Space in which pupils should now be given opportunities at Key Stage two to 'consider a wide range of patterns,

including some drawn from different cultural traditions' (SCAA *op cit)* as well as perhaps making the more traditional links with geometric shape and transformation geometry.

However there are other links in pattern as defined as early algebra and in areas such as probability. Number patterns, particularly the Fibonacci sequence and its relationship to the golden ratio, also have links with art.

4. A search for pattern

The link with pattern is interesting, as the concept appeared formally when the attempt was make to define Algebra in the first two Key Stages. Children were asked to 'copy and continue a pattern' (NCC 1989), for example. Mathematics educators have now started to define pattern from a mathematical point of view (Orton 1993) and research the concept of pattern (Orton, Orton, Threlfall & Garrick all 1994).

Another manifestation of the concept of pattern for young children is in the introduction of the concept of probability, formerly not met until much later. One view is that randomness might be viewed as the absence of pattern and that the mathematical models brought to bear to impose order upon randomness could be termed second order patterns (Roper & MacNamara 1994).

5. A changing view of Art in school

The development in the Mathematics curriculum in England and Wales has been echoed a few years later by that in art. In both cases the new curriculum orders were based upon the best of existing practice but which was acknowledged not to be the normal practice across all classrooms.

The specification of 'Knowledge and Understanding' in art has enabled teachers to justify more overt links both with the work of artists and with a variety of craft and design artefacts to extend pupils' understanding of their cultural heritage. The requirement for the development of visual literacy in 'investigating and Making' has enabled pupils to develop a vocabulary with which to discuss these. Some of the vocabulary is also that used in mathematics, for example, shape, space, colour, pattern, line, and the similarities and differences of this vocabulary between the two subjects needs to be explored so that the relevant concepts can be developed and to avoid confusion.

6. A consideration of the affective aspects of Mathematics education

One concern of mathematics educators for some years has been in the affective domain. Mathematics, dealing as it does with abstract entities, is regarded as a difficult subject which many pupils come to dislike. This can stop them learning even before they have engaged the cognitive processes. Buxton (1981) found it appropriate to title his study of maths anxiety 'Do you panic about maths?' and there has been considerable concern about the low take-up of mathematics by girls (e.g. Hawkin 1986; Burton 1986; Smith 1987).

Linking Mathematics with areas of the curriculum which are seen as more 'user friendly' such as embroidery or Art has thus been a strategy of mathematics educators (e.g. Harris 1989). However This perhaps makes assumptions about

pupils' attitude to Art which can often also be a sense of failure. Discussions with REd. and PGCE students reveal that 'I can't draw' is an attitude of failure engendered as a result of experience at school.

7. Children's representation of the environment

In both art and mathematics there is a need for children to map their 3-D experience on to a 2-D representation. This has generated considerable research in art (see for example Matthews 1991) and some in mathematics.

Literature linking art and mathematics education

At this point I shall look at some of the books which are commonly used as a resource for linking Art and mathematics in the classroom. In particular to examine their stated view of art and mathematics which will inform how they make the links.

At its most trite the primary teacher has on one occasion been encouraged to make paper chains with the colour sequence predetermined by a number sequence generated by the times tables. The colours which each digit should stand for were given in advance and the paper chain was constructed in accordance with the chosen sequence of numbers. One member of the class was colour blind, so this became a problem. The result was a brightly co loured chain which could be used to decorate the classroom. I am not sure whether this is Art. I am not even sure it is Mathematics, although it was during a mathematics conference. Art was in this case defined as decoration.

At a similar level Math in Art (Taylor 1974) refers to activating "a child's passive knowledge about the universe and [motivating] him to his own creative problem solving and resulting creative self expression." "Symbols in man's art", we are told, "use geometric forms" and basic art concepts are given as "colour, line, form, space and texture" and this list is developed further giving a clear message that this book comes from art.

Many primary teachers are familiar with the Woodman and Albany book Mathematics through Art & Design 6-13 (1988). In the introduction a definition of mathematics by W W Sawyer is given: "The classification and study of all possible patterns and relationships. Pattern is anything the mind can recognise as regularity." The justification of links with art is in terms of creativity and "Children will be led to look upon mathematics as a more attractive subject if we draw their attention to the balance between its functional and its aesthetic aspects".

Here a carefully graded series of activities is set out, mainly related to the mathematical ideas of rotation, reflection, translation, area and tessellation and 3-D work. In each case the result will make an attractive display and the activities are very popular with mathematics specialists who see them as a way to do art. Each activity is described in sequential steps and a box gives the relevant vocabulary. However this vocabulary is almost entirely mathematical.

Teaching Mathematics and Art (1991) is an interesting miscellany of a book aimed at secondary teachers and edited by Lesley Jones. A very clear statement is given in the

preface that "artwork which appeared to contain mathematics had not been considered in that light. Similarly, mathematics which could be used to develop an aspect of art had not been used in that way". She also acknowledges that "there is clearly a distinction between the kinds of judgements we make in mathematics and art" and the philosophy of the first chapter discusses this. There is also an acknowledgement that this view of mathematics is biased towards the geometric aspects and that art is projected is a largely two-dimensional form with considerable emphasis on pattern, but that each subject could have further contributions to make.

Teaching Maths through Islamic Art (1993) produced by the Victoria & Albert Museum was presented in a folder at a Mathematics conference earlier this year. This implies that it has some good mathematics in it. It discusses the principles of Islamic design and also geometry in Islamic Art, covering mainly the symbolism of the shapes and their use. Mathematics is also defined in terms of the relevant National Curriculum ATs, an increasing tendency.

Art & Maths by Grant Jones is from East Sussex County Council of which the date must be between 1989 and 1991 as it refers to the original 14 Mathematics Attainment Targets. This sits between the two subjects in some ways as it draws from specialists in both Art and Maths. It does not try to define Art or Maths, except the latter in terms of A Ts covered.

Rob Barnes has a chapter on Art from Mathematics in Art, Design and topic work 813 (Barnes 1989). This is coming from the view of art. In an earlier chapter on 'What does Art do?' he examines the nature of Art which he says is "essential for an understanding of the world we inhabit" (Barnes 1989, p.24). The mathematician would argue in exactly the same terms. Mathematics is described in terms of having 'rules and formulae' which would suggest that this is a 'content' view of maths, however this is mediated by a discussion of investigational ways of working such as considering "what if not".

Barnes also suggests that art is difficult to understand when abstract. It is because mathematics is abstract that it is difficult to understand and that is why different strategies have been suggested to make it more visible and concrete for children, including linking it with art. I note that Nuffield have a module on art and music in their new A level, but have not discussed this.

Discussion and conclusion

Some of the works detailed above focus on the mathematics and some on the art. This can often be detected by looking for a definition of art or mathematics within the piece itself. Many authors and educators discussing concepts from within the subject itself do not address the issue of what the subject entails. Mathematics literature has begun to do this (see above) but it is often implied in many texts on art education, assuming insider knowledge. Mathematics has the advantage of an HMI publication in the series 'Curriculum Matters' *(op cit)* which states the aims of mathematics teaching (in order, these are given as: an essential element of communication; as a powerful tool; appreciation of the relationships within mathematics; awareness of the fascination of mathematics; imagination, initiative

and flexibility of mind in mathematics; working in a systematic way; working independently; working co-operatively; in-depth study of mathematics; pupils' confidence in their mathematical abilities). The comparative art document was written but not published (per NSEAD conference 1994).

One must search hard in the National Curriculum documents for any definitions. In the non-statutory guidance both subjects attempt to describe their subject. Mathematics refers to key documents and also has a large section (2.1 to 2.13) on the nature of mathematics in the National Curriculum which includes statements such as:

> *Mathematics provides a way of viewing and making sense of the world. (2.1)*
>
> *Mathematics also provides the material and means for creating new imaginative worlds to explore. (2.2)*
>
> *Mathematics has the capacity not just to describe and explain but also to predict. This gives mathematics the power and pervasiveness that accounts for its importance in the school curriculum. (2.3)*

Mathematics, unlike Art, also has quite a long section (F) on cross-curricular work.

Art is defined in the non-statutory guidance as distinct from Technology (D 3.7):

> *National Curriculum art occupies the middle ground between (applied graphic and visual skills as in commercial and industrial design activities and the expressive, conceptual processes of fine art); it is not fine art only.*
>
> *The unique characteristics of art in the National Curriculum include: the emphasis on visual literacy; specific technical skills; harnessing observation, memory and feelings in order to express and communicate ideas in visual form; a distinct body of knowledge; response to the work of artists.*

Both subjects see themselves as describing and explaining the world, but in different terms. Mathematics as well as art has a new emphasis on visualisation. The difference with art seems to be that has a special emphasis on expression and response. If links are to be made between the two subjects which, under Barnes's criteria, "develop and respect the core concerns of the subject" this expressive aspect must be maintained.

I suggest that the most successful links between art and mathematics seem to be where the starting point is the work of an artist. Mathematics can then be used to describe and analyse the work. This might include examining any mathematics that has been used in the construction of the original work either explicitly or implicitly. It might also include an analysis, for example, of the shapes and relationships intuitively produced. It is essential that this mathematical analysis draws on and develops specific mathematical concepts so that mathematical learning can take place.

If this analysis is not to be a sterile process, I further suggest that the results of this mathematical analysis should then be used to generate pupils' own art work. This is

not suggesting direct plagiarism, but using the principles involved to have an insight into how the artist may have worked and to produce examples which might relate to the genre. If each pupil is given the freedom to apply rules, the results should be a range of different but related works, each exhibiting creativity because of the way that the mathematics has been applied.

The validity of this approach comes because in mathematics pupils are 'Using and Applying' their mathematics in a real life context at the same that they are linking both 'Investigating and Making' and 'Knowledge and Understanding' in art.

[In the session at which this paper was presented, examples of children's work using this approach were shown, based on '123454321' by Sol Ie Witt at Yorkshire Sculpture Park.]

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