Art in maths

Melissa Rodd

UCL Institute of Education

This paper discusses what 'art in maths' might mean through presentation and discussion of a set of examples of visual art or visual mathematics. The examples have been chosen to show interfaces between mathematical and art practices and each of the examples is interpreted for a mathematics education context.

Some contemporary issues related to STEAM (Science, Technology, Engineering Arts, Mathematics) concludes the paper.

Keywords: Visual art; creative practices; slow mathematics; agency

Introduction

The title 'Art in maths' is intended to evoke a certain informality as well as some ambiguity; the word 'maths' has an educational tone (even though mathematics educators generally eschew it). Enquiry into 'art in maths' - the topic of this paper - is both collective and personal; it includes both considering what 'art in maths' might mean and also investigating what practices of art in maths there are and how, or whether, these practices afford a positive relationship with whatever maths or mathematics might be. That is all pretty vague. Let us keep the ideas loose else there is a risk of specifications, demand for observables and steaming attainment targets. The reason 'art in maths' has been kept as a touch-base is that the phrase suggests experiencing art within mathematics. This paper is intended to open up this idea; there are no empirical claims, though a plea based on theoretical considerations for less measuring of observables is an intended consequence. It is not the case, for me, that "If you treasure it, measure it!", indeed, quite the opposite. Against the current grain.
The outline of the paper is as follows: the main body of the paper consists of exemplifications of 'art in maths'. These are presented to stimulate a query as to whether the example seems, to the reader, to be - or seems not to be - an instance of 'art in maths'. There is no formal 'literature section' section due to the huge range of intellectual bases to this topic and that this is a short paper. The concluding discussion looks very briefly at 'creativity' in current educational discourse and the term's relationship with 'art in maths'.

Exemplification of 'art in maths'

Examples of what 'art in maths' might mean are given below. The key criterion for inclusion is that the example involves a person's 'practice' of production of something visual and has mathematical aspects (which may or may not be important or even obvious to the person producing the visual artefact). 'Practice' is used in the social science sense and connotes what the practitioner spends their time doing, how they represent what they do and what they attend to in their work.

Maryam Mirzakhani (1977-2017)

The working diagrams produced by the mathematician Maryam Mirzakhani, the first female Fields Medal winner, exemplify how producing diagrams can be an art experience. In Mirzakhani's words "when thinking about a difficult math problem, you don't want to write down all the details; the process of drawing something helps you somehow to stay connected" (Cook, 2017).

Fig 1. Drawing as a process that sustains connection to a difficult math problem.

In this sample diagram a viewer can observe curiosity-provoking, related shapes positioned in a lively manner. The purpose of producing these marks is to 'dwell' in their production in order, as a research mathematician, to be alert to something new in her exploration of mathematics. Indeed Mirzakhani referred to herself as a slow mathematician, letting ideas simmer before considering them ready. This dwelling in experience in order to internalise mathematics and be alert to the new is available to mathematics learners too. The task 'construct a square within a square and repeat' not only leads to the image of a square spiral and associated curves of pursuit but also opportunity for experiencing that care in measuring matters (else the square turns agley) and also for experiencing agency in choice of colour and texture. The 'Artful maths' website (Grandi, 2016) presents some fine, well-known examples of school maths tasks that afford dwelling in production.

Vi Hart (b. 1988)

Vi Hart is a contemporary artist/musician/mathematician who advocates through her media presence motivating and engaging roles of art-based approaches to mathematical enquiry. Her videos subvert conventional classroom norms and demonstrate how mundane 'school math' can be injected with art practices affording student agency and creativity. For instance, Fig 2. is a screen shot from her video on 'dragons' where the school math item-to-be-learnt is logarithms but the subversion morphs into fractals (Hart, 2013).

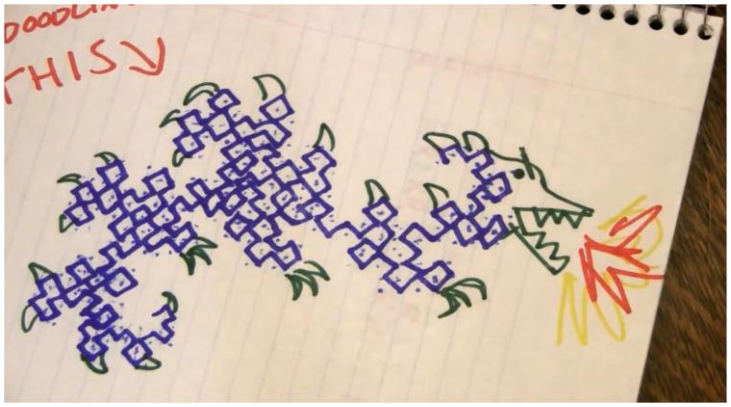

Fig 2. Fractal dragon appearing in a math class on logarithms

More recently Vi Hart has written on the creative process in mathematics:

> In my experience, and in the experience of many mathematicians I've known, pure math research has more to do with feeling than you'll see reflected in a math paper.
>
> First you have a feeling about something. You just know it's true, or that it wants to be true, or that it must be connected to this or that. You'll prove exactly why that is only in retrospect, and write it up as if you proceeded perfectly logically. And sometimes you're wrong. But right or wrong, how would we ever find out without first an un-proved feeling about what to explore?
>
> What is this feeling and how do we develop it? (Hart, 2019)

Arguably, this feeling is of 'art in maths'. And engaging in the kind of visual art creative mathematical practices that Vi Hart designs and communicates herself might well be a way to develop it.

Masaccio (1401-1428)

Renaissance visual art was also pragmatic science. Renaissance geometers such as Masaccio or Piero della Francesco put their geometrical work into practice in their art. In the well known 'Tribute money' (by Masaccio, 1425), if sets of parallel lines in the 'reality' of the painting (like the ceiling and floor of the porch) are drawn in they will have their vanishing point at Christ's head. This technique was devised from mathematical principles being developed at this time.

Fig. 3 'Tribute Money'

Without knowing or needing to know Masaccio's plans for his painting, it is possible, even from the 21st century, to imagine that having various principles of perspective (as mentioned above), he created a devotional picture, putting art back into the

mathematics. This painting, which guides the viewer's sight to Christ's head, is thus an example of art in maths (as well as more obviously mathematics in art). The art is in the development of the mathematics and fleshes the mathematics in the production of this painting. Drawing Celtic knots (Bain 1951) has motivated many students I have taught to use mathematics to produce the beautiful by appropriate precision and through their creative work they have learnt about mathematics such as factors, angles or networks.

M. C. Escher (1898-1972)

M.C. Escher is an icon of 'math-art' culture; much of his work has mathematical meaning – for instance, use of symmetries, representations of limits and depictions of 'impossible objects' – and entails a precision that is recognisable as a result of mathematical skill. Nevertheless, Escher says about his mathematical background:

> I was an extremely poor pupil in arithmetic and algebra, and I still have great difficulty with the abstractions of figures and letters. I was slightly better at solid geometry because it appealed to my imagination, but even in that subject I never excelled at school. (Schattschneider, 2010: p706)

Fig. 4 shows Circle Limit I ('CL1' on the left) and Circle Limit III ('CL3' on the right); these two art works can serve as teaching aides for introducing Poincaré geometry (a negatively curved geometry that can be realised on the unit disk): shown in red (CL1) are some of the 'straight lines' (i.e., hyperbolic geodesics) of this geometry and the white lines within the painting in CL3 are not generally geodesics.

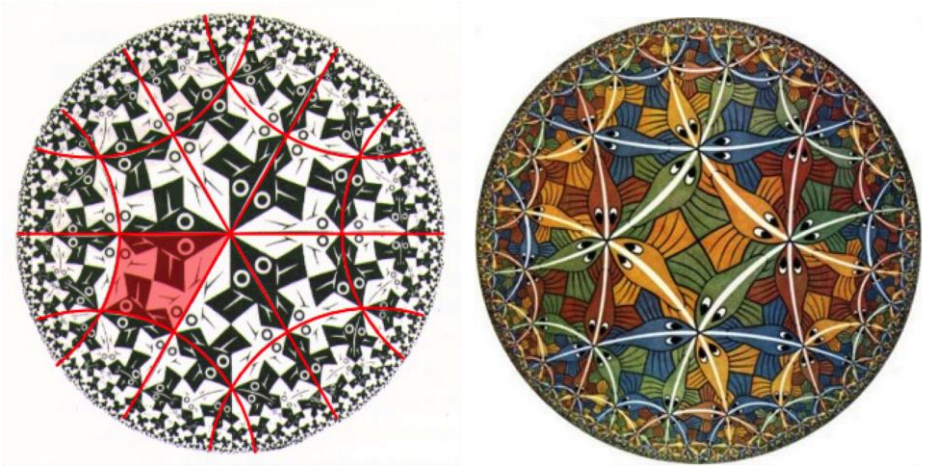

Fig. 4 Circle limit I and III: hyperbolic geodesics (I) and their near miss (III)

This example is intended to provoke the idea of encouraging the less algebraic/ numerically skilled students to experience mathematics of graduate school (non-Euclidean geometry) via art to maths. Grasping the non-geodesic nature of the lines in CL3 develops the capacity for using/understanding tools (compasses or digital equivalent) and the capacity for visual appraisal of constructions.

Antony Gormley (b. 1950)

Antony Gormley has had a recent exhibition at the Royal Academy, London (Royal Academy, 2019). Artwork exhibited included Gormley's notebooks, custom-installed sculpture and retrospective works many of which had mathematics at their core. For instance, Three Dimensions (see Fig. 3), consists of three, non-intersecting, steel

wires extending as far as they could vertically and in two perpendicular horizontal directions giving the sense of *x*,*y*,*z*, axes but subverting that sense by their skewness.

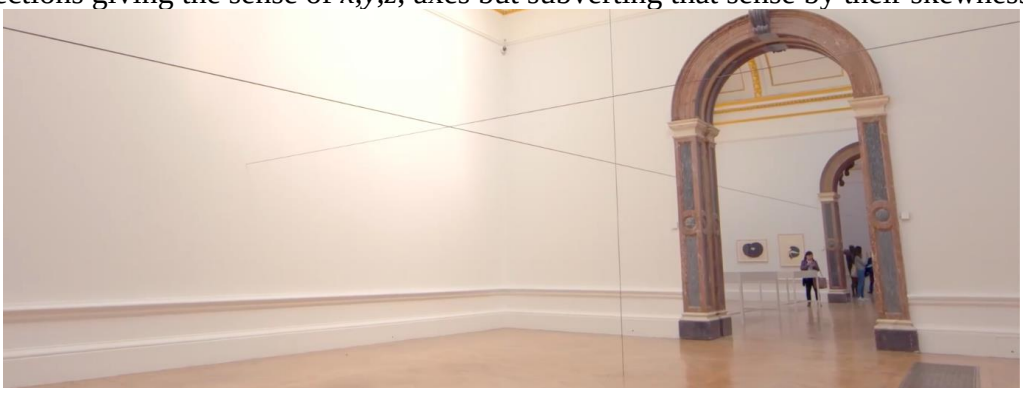

Fig 5. 'Three dimensions'

Other art works included: Matrix III (which is an enormous metal 3D grid) and a room in which about 20 copies of Gormley's well-known iron-cast body hung from ceilings and walls in ways seeming to defy gravity. A curious thing about the exhibition notes for the Gormley exhibition was, from this mathematically trained viewer's perspective, the lack of the 'm-word' (mathematics!) even though practices recognisable as mathematical pervaded the space. This provokes the mathematics education query: What would it be like to teach mathematics without mentioning 'mathematics'? and, by reflecting on the Gormley exhibition, it seems that through 'art in maths' it would be possible.

Artists/mathematicians not exemplified here but to be incorporated into a subsequent discussions include: Roger Penrose, Bridget Reilly, Barbara Hepworth, Naum Gabo, Tony Cragg, Tarquin publications and the Bridges Organisation.

'Creativity', mathematics education and 'art in maths'.

STEAM is a newish acronym, where 'A' is for 'Arts' and STEM stands for Science, Technology, Engineering and Mathematics. There are two principle motivations for the insertion of 'A': to attend to creative industries' needs and to infuse a creative dimension into STEM study (Colucci-Gray et al. 2017). In the British Educational Research Association (BERA) review of STEAM just cited, authors noted that there was less educational research available concerning Mathematics and Arts than there was about Science or Technology and that Arts in Mathematics was usually an individual teacher-led innovation. In a more recent publication, a subset of the BERA review authors position the discussion of STEAM within a contemporary discourse:

> STEAM education that have been promoted as a pedagogical response for "a new Renaissance" to meet the economic and social needs of post-industrial societies. Since the birth of civilization, people working in different scientific and arts fields have been inspired by phenomena that involve the combining of different disciplines, creating something new by thinking across boundaries that at first may seem incongruous. It is these ways of thinking that bring new literacies and diverse creativities. ... We need different curricula designs and pedagogies to re-present, re-configure, and revision the ethos and purposes of "creating," "making," and "remaking," as the essential acts for a more eclectic, humanizing, and sustainable education. (Colucci-Gray, Burnard, Gray, & Cooke 2019: p22).

And while these are fine words, there is negligible mathematics education detail. However, in the preamble to the Mathematics National Curriculum for England, the word 'creativity' is used and is linked to aesthetic experience:

> Mathematics is a creative and highly interconnected discipline … A high-quality mathematics education therefore provides … an appreciation of the beauty and power of mathematics, and a sense of enjoyment and curiosity about the subject. (Department for Education 2014).

Nevertheless, an agreed definition of creativity is as hard to find as is an inclusive way to implement it throughout school populations. Part of the STEAM agenda is to increase participation in disciplines such as maths, science and tech. Hence the discussion comes back to a quest to develop inclusive practices that offer learners opportunities for attention-holding practice that gives them positive feedback and a feeling of agency as they do their work. And 'art in maths' can do this, for, if/when you experience 'art in maths', you are primed for participation; participation might be in art or in maths or in new creative boundary-crossing practices (as imagined in the 2019 quotation above).

In conclusion, in mathematics educational contexts, learners can experience 'art in maths' either through engaging with visual art practices that have mathematical interpretations/foundations or through experiencing mathematics through aesthetically satisfying visual representations. These types of creative pedagogies require a teacher's skill and commitment and their school's understanding and support.

References

Bain, G. (1951). *The methods of construction of Celtic art*. Glasgow: W. MacLellan.

Colucci-Gray, L., Burnard, P., Cooke, C., Davies, R., Gray, D., & Trowsdale, J. (2017). *Reviewing the potential and challenges of developing STEAM education through creative pedagogies for 21st century learning*. London: The British Educational Research Association.

Colucci-Gray, L., Burnard, P., Gray, D., & Cooke, C. (2019). A critical review of STEAM (Science, Technology, Engineering, Arts, and Mathematics). In *Oxford Research Encyclopedia of Education*. Retrieved from *https://oxfordre.com/education/view/10.1093/acrefore/9780190264093.001.0001/acrefore-9780190264093-e-398?rskey=JQvu9H&result=1*.

Cook, G. (2017). Maryam Mirzakhani: She drew her way to mathematical greatness. *New York Times*. Retrieved from *https://www.nytimes.com/interactive/2017/12/28/magazine/the-lives-they-lived-maryam-mirzakhani.html*.

Department for Education. (2014). *National Curriculum in England: Mathematics programmes of study*. Retrieved from *https://www.gov.uk/government/publications/national-curriculum-in-england-mathematics-programmes-of-study/*.

Grandi, C. (2016). *Artful maths.* Retrieved from *https://www.artfulmaths.com/about.html*.

Hart, V. [vihart] (2013, August, 19). *Doodling in math class: dragons*.[video file]. Retrieved from https://www.youtube.com/watch?v=EdyociU35u8.

Hart, V. (2019). *A history*. Retrieved from *https://theartofresearch.org/a-history/*.

Royal Academy. (2019). *Antony Gormley*. Retrieved from *https://www.royalacademy.org.uk/exhibition/antony-gormley*.

Schattschneider, D. (2010). The mathematical side of MC Escher. *Notices of the AMS 57* (6) 706-178.