# Proportional Thinking and the Materiality of Monoprinting

Tam Dibley

Education and Social Research Institute, Manchester Metropolitan University, Manchester;
tam.dibley@stu.mmu.ac.uk

## Abstract

This workshop will introduce participants to a monoprinting technique using gel plates and paint to print onto card, through a project in which we will collectively reproduce a satellite image of the Aalto University Campus. We will discuss the types of mathematical thought involved in the translation and deformation of shapes and images through these processes and how these issues relate to experiences and topics raised whilst running a similar project with students of early years education.

## Introduction and Aims

The workshop will allow us to explore the possibilities of a monoprinting technique using paint and gel panels, and to discuss what is implied by monoprinting in general and how it can relate to mathematics and mathematical learning. We will do this in the context of a project in which we collaboratively recreate a satellite image of the Aalto University campus by combining multiple printed panels. Starting from an original image, we will move through the multiple steps of decision making and the monoprinting technique, seeing how each influences the final outcome. We will consider how each step is managed, what we are or are not able to control in it; what we see in the outcome that is unexpected; and what kind of mathematical ideas and objects are involved in this. Some steps require conscious decisions, such as what geometric images we pick out from the original map and how we place them, what colours we use, and how we layer each print. Other decisions are less clear cut, such as how much paint we apply to the gel pad, how much pressure we use to print it, the precision with which we place pieces. Some steps require clear problem solving, such as visualising the print resulting from the placement of stencil pieces. We will focus on this step in particular as an instance of mathematical reasoning and problem solving within the process.

We will discuss the types of mathematical thought involved in the translation and deformation of shapes and images through these processes. In the paper, I will elaborate on an example of proportional reasoning, in which a group of students manages the process of producing their initial, sketched reproduction of the satellite image. I will also briefly introduce some lines of questioning in relation to mathematical thinking in creative work and play with materials, drawing on the thought of Friedrich Froebel, and how unpredictability in the processes of mapping and monoprinting creates potentially productive tensions between the drive to correctly reproduce the image, and to engage with uncertainty.

## Background and Theoretical Framework

This workshop is adapted from a course taken with undergraduate students at Manchester Metropolitan University. The original aim of the class was to allow students of early years education to consider how the material processes of art and craft could offer opportunities for learning. The ideas of artistic abstraction and problem solving were central to this, and a number of abstract artists were discussed as important precedents to the work we were asking them to complete. The processes of abstract art often work in a negotiation between what is conceptually important for the work, and the materiality of its creation. In the classes, we encouraged students to question their assumptions about what they were trying to achieve with the final piece by engaging with the unpredictability of the monoprinting process and the complexity of the properties of the materials involved. At the same time, the ongoing drive of students to take control of and understand the process would lead them to problem solve and to find methods to predict the outcome of the prints, producing generative tensions through the process.

The students were in training to work as early years educators, with children between the ages of 1 and 5. Central to our approach was to engage students in creative explorations with materials which might help to situate their thoughts in the type of informal, play-based learning which is commonly associated with very young children. A key reference for us whilst planning these classes was the work of Friedrich Froebel. Froebel is credited with inventing the Kindergarten in 1830, and his educational system for early years centred on the use of a series of "gifts" - specifically designed sets of objects intended to be introduced to children at particular ages. The gifts would increase in complexity corresponding to the increased dexterity and ability of the children to make use of them, and ranged from very simple sets of cubic blocks, to more complex, larger sets including triangular prisms and more varied dimensions of block, and onto other objects including sticks, rings and natural objects such as pebbles and seeds.

Froebel's intention was for educators to prompt children to use the blocks to engage with what he called the "Three Forms", which included "Forms of Knowledge" (abstract relations of shape afforded by the blocks), "Forms of Life" (the design or representation of real-world objects such as buildings or furniture), and "Forms of Beauty" (usually planar configurations of blocks foregrounding the aesthetics of symmetry and pattern) [6]. This diversity of ideas are all entered into via the lens of the sets of simple 3D shapes, engaging children in the world of possibility afforded by them, and in the process strengthening their relation to shape and practices of geometric construction in three dimensions. The use of Froebel's techniques and gifts has often been cited as influential in relation to the work of key figures in Architecture and Art, including Frank Lloyd Wright and Wassily Kandinsky. We see in the work of these creative practitioners how basic geometric concepts such as the point, the line, the grid and the most simply defined mathematical shapes carry meaning in relation to wide spheres of thought.

In Froebel's system, work and play with the "gifts" in early years would lead to work with what he called "occupations", which meant creative play with materials like clay and paint. The core ideas of Froebel's philosophy remain in these stages, but the relatively simple properties and modes of combination of objects such as blocks are now replaced with the more complex and unwieldy properties of arts materials. The mathematics of a material like clay or paint is one that is much less graspable or definable than that of a geometric block, but it nonetheless underlies any work done with it. Becoming competent with these materials signifies mathematical thought in a similar way that the use of blocks does, in embodied work which connects the properties of the material to the "forms of knowledge", "beauty" and "life". Our approach to teaching the classes, was a way to enter into a version of this pedagogical approach through first hand experiences of the types of learning which arise through creative work with materials.

For the tasks in the classes, we chose arts techniques which seemed to offer specific opportunities for learning under this approach, a central one being that of monoprinting. Monoprinting refers to a range of printing techniques which, contrary to common conceptions of printed media, do not produce predictable or repeatable results but in each instance a unique print. It has been considered useful in arts therapy since it requires the artist to somewhat release control of their vision of the outcome and embrace unpredictability in the process [3]. The multiple steps of the monoprinting process "create distance from the final outcome so, many times, the self-consciousness of the accuracy of a shape or object to be portrayed is minimized during the process due to the seeming disconnect from the final picture" [2]. Mathematics educators such as Borasi [1] have discussed the importance of experiencing mathematics through open-ended inquiries, in which errors are capitalised on as "springboards for inquiry". This approach is similar to what we have tried to foreground in the mapping and monoprinting project, in which unexpected deformations and imperfections are made central to the appreciation of the final piece.

In the process of the mapping and monoprinting project, mathematical ideas such as proportional reasoning and the concept of mirror images are encountered in the context of different requirements of the process. For example, as we will consider in more detail, a form of proportional reasoning is required when translating an image to a canvas of differing dimensions and mirror images are encountered in the need to visualise the inverted outcome of a print. Each of these encounters has a context which has both a practical aim (the requirement to complete that step of the process); a material context; and an aesthetic dimension, requiring students not only to engage with logical reasoning, but to make judgements of that reasoning and its effects on the final piece. These ways of interacting with mathematical ideas differ from the traditional use of numbers and measurement, allowing for an embodied engagement in which materials are implicated [4][5]. Many now advocate this form of mathematical interaction, not to replace the use of number or the traditional learning of method but to allow alternative ways of thinking and acting with these mathematical ideas or objects.

## Workshop Plan

This 90-minute workshop will include three periods:

***Period one – Introduction to Monoprinting and Mapping:*** Background of the project and current lines of questioning (5 minutes). Introduction to Monoprinting and Demonstration (10 minutes). Introduction to the mapping project / Split participants into pairs / Give time to discuss and decide on the area to be mapped and the scale (10 minutes).

***Period two – The Project (45 minutes):*** Each participant will create at least one monoprinted panel, adding to the collaboratively produced recreating of the given image.

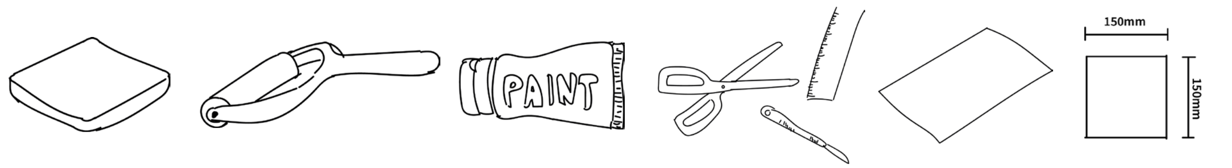
***Period three – Discussion (20 minutes):*** Each team will share their completed project and discuss thoughts on the process.

## Monoprinting

The monoprinting technique we will be introducing is one which makes use of paint and gel plates to print onto card. This particular printing method requires only minimal equipment compared to many others, and can produce results quickly making it a useful method in educational contexts. Below the requirements for carrying out the workshop are given in detail.

**Figure 1**: *Examples of monoprints made using paint with gel plates*

## Monoprinting Process




*150x150mm gel pad [7]* | *Roller [8][7]* | *Acrylic Paint* | *Scissors, Craft Knives & Metal Rulers* | *Scrap Card (for stencils)* | *150 x 150mm blank card (for printing)*

*eference items [6] and [7] give sources for materials)*

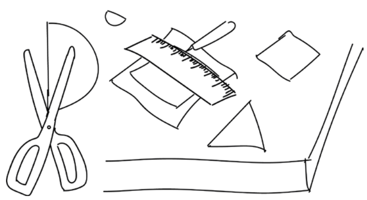


**Figure 3:** *Step a - Cut stencil pieces to the correct shapes for your print*

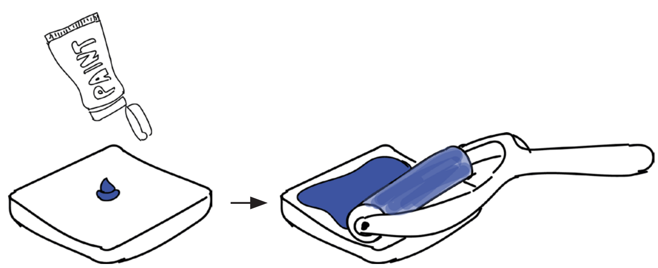



**Figure 4:** *Step b - Apply chosen colour of paint for first layer to your gel panel with roller*

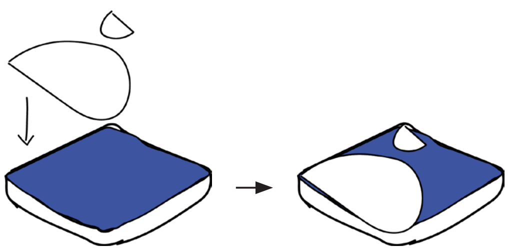


**Figure 5:** *Step c - Place stencil shapes on gel panel over paint*

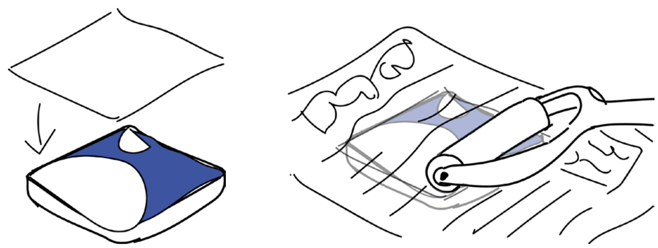


**Figure 6:** *Step d - Place your 'canvas' (150 x 150mm card) over the paint and stencil shapes. Cover with newspaper or scrap paper and roll to ensure paint is applied to the surface.*

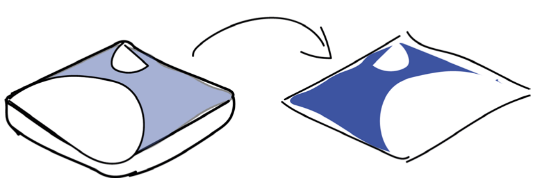


**Figure 7:** *Step e - Remove card to reveal print*

**Figure 8:** *Step f - Clean gel panel under a tap or with a rag and water.*

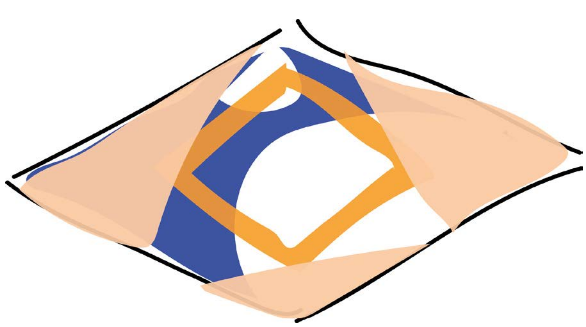


**Figure 9:** *Step g - Repeat steps 2 - 6 as many times as you want, to layer different patterns onto your card.*

## Mapping Project

The mapping project makes use of the monoprinting technique described above to reproduce an image whilst allowing the materials, techniques and various decisions to define a transformation of the given geometric images. Below we see an example, taken from undergraduate classes, showing the transformation from satellite image to a collective reproduction constructed of a number of monoprinted panels. This task situates the process of monoprinting within a broader project which adds a collaborative aspect, and allows an open inquiry into place, shape and representation.

**Figure 10 (above):** *Original A4 satellite image given to students*

**Figure 11 (below):** *Final piece combining 8 monoprinted panels (600mm x 300mm)*

## Additional Materials and Steps in Mapping Project

***Materials:*** Satellite image of area to be reproduced, paper and pencils for sketching (Including one piece of paper of the overall dimensions as the finished piece, for sketching the plan and cutting stencil shapes from), mounting board of the correct size to stick all printed panels to for completed project (e.g. for image shown in Figure 11, Length = 600mm and Width = 300mm), glue or double sided tape

***Steps:*** **1.** As a group select the area on the image to be reproduced. **2.** Sketch out the area from the satellite image onto the large piece of paper/card. As shown above, the proportions between the satellite image and the prints may be different - this translation can be explored as part of the creative process and form part of the mathematical side of the inquiry. **3.** Divide the area into separate blocks to be printed individually, and allocate them between members of the group. **4.** Cut stencil pieces from card and follow the monoprinting process to create each print, before rearranging together for the final piece.

These steps are one possible way to generate the final image, but it may be enough to present students with the materials and instruction on monoprinting, allowing them to work out a process which works for them.

## Proportionality, Problem Solving and Productive Tensions in the Process

In the spirit of Froebel's approach to early years learning, our classes aimed to engage students of early years education in work with materials as a way to situate their thoughts in a state of open exploration similar to one in which very young children might find themselves. The process we will go through together at Bridges should provide similar opportunities for participants. Without seeking to restrict the range of mathematical ideas that could be raised by such an approach, we will explore in more detail an episode from the classes, and specifically in this episode, how a group of students tackles the issue of proportional relations as they translate the satellite image onto a sheet of different dimensions (see Figure 12).

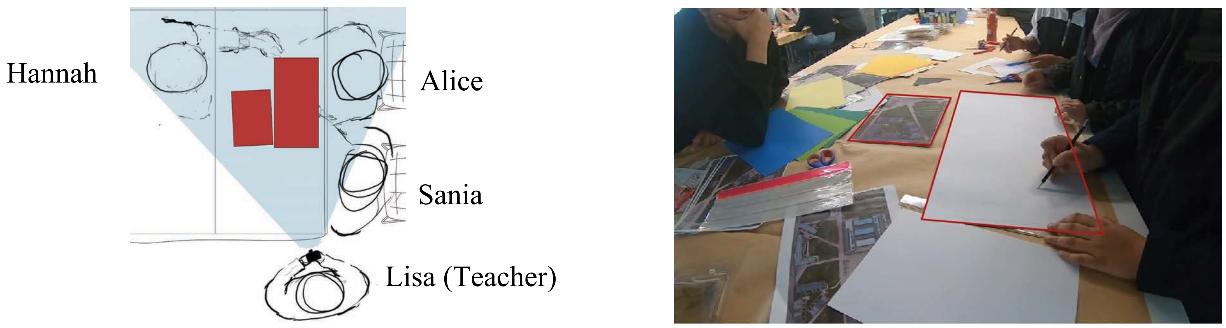



**Figure 12:** *Plan view (left) and still-frame (right) of scene, indicating satellite image and blank sheet*

They started by identifying elements from the satellite image which are appropriate to feature as parts of the sketch and the final prints. The first of these elements chosen is a long road which traverses the satellite image diagonally. Here they are already dealing with proportional relations, and the road is chosen not simply for what it symbolically represents, but for its spatial properties as a line which provides proportional structure to the image as a whole, relating directly to many other areas as it passes across the image:

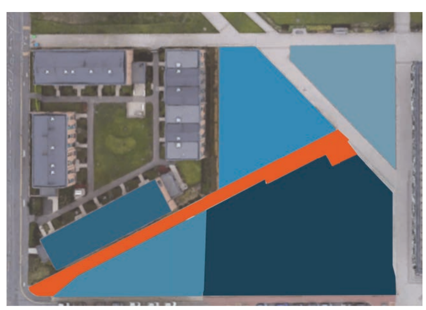


**Figure 13:** *Satellite image showing the road (in orange) and areas around it (in blues)*

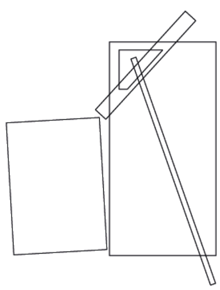
As they go on translating between the satellite image and the sketch, this line plays a key role in the arrangement of all other elements around it, and the image as a whole. After identifying the road as the first element, but before drawing it onto the white sheet, there is a discussion about the difference in proportion between the satellite image and the paper they will sketch onto.

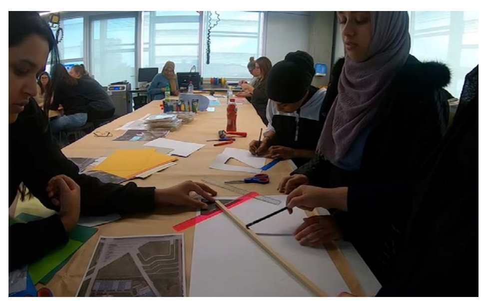
> Hannah: So, you're stopping *there* or should we make it a bit thicker or thinner?
> Alice: *[After a pause looking over the area]* Yeah that's fine
> Sania: Are you sure?
> Alice: Yeah
> Sania: ...cause that triangle looks small and that grass is gonna be massive

Lisa (Teacher): [but you see what happens] that the shape of this is shorter *[Indicating the A4 image]* and this one is more elongated *[Indicating the blank sheet]*
Alice: Yeah
Lisa (Teacher): so you will have to deform some shapes you cannot do it realistic

The Teacher, Lisa's, intervention here is to encourage them to accept that they will have to "deform some shapes" and "cannot do it realistic". The question of proportionality isn't dropped here, but is still central to the enquiry of the students as they continue the sketch. They explore it, however, through an open inquiry in which there are many possible "deformations" that could occur from their attempts to translate between the two, rather than a single correct method and outcome. Students continue this exploration throughout their their sketching, as they continue to identify and consider the combination of elements in the satellite image, and make decisions about how and where to place them. The understanding which is opened in Lisa's intervention that they "cannot do it realistic" allows a certain freedom of expression now in the way elements may be placed, but with limits, since they cannot entirely let go of the proportional relations between elements given on the map. Some students seem to be more unsure or unsettled by this approach, whilst others are quite readily able to accept this uncertainty.

Navigating the tension of this uncertainty is something they must manage through the process. Part of the way they do this is to bring in objects to symbolise and materialise certain elements in the sketched version of the satellite image. By the time the road is drawn onto the map, the students have gathered a number of items from around the desk and classroom: a long piece of wooden dowel, a small triangular piece of black card and a translucent, coloured ruler; each of which symbolises and plays the role of a particular element of the satellite image.





The properties of these objects relate to parts of the satellite image. The straightness and length of the dowel corresponds to the similar features of the road, the triangular piece in the corner matches the shape of the area it represents, and the transparency of the ruler allows them to observe its relation to this corner piece when placed over it. There are proportional relations at work here, but they seem to be defined at least partly by the availability of the things around them, whose properties allow them to become symbols for elements of the satellite image, without bearing exact proportional relations to them. We see in the bringing together of this assemblage of items some relation to the thought of Froebel in the way the image is constructed through the properties of objects, and how these items come to relate to a wider sphere of thought encompassing the satellite image, and through it, the grounds of the building they are in.

This part of the project occurs prior to printing, but already attempts to introduce the idea that the translation from the satellite image to the final prints will not be a simple reproduction but a transformation or deformation of that image, involving both conscious distortions and the unpredictable effects of improvisatory work with materials. Monoprinting further augments this process by bringing in other materials and processes, further distorting or deforming the final result from the original image. There is not a complete removal of judgement from the process, but rather a sense of actively engaging with parts of the process which are not entirely reasoned or predictable and allowing them to shape parts of the outcome, whilst still retaining control over other elements of the process. Observing and appreciating how the final print differs from the original image means neither attempting to perfectly reproduce it nor completely disengaging with it, instead sustaining a tension between the pull of these two poles and continually reassessing what is important to the work. This involves engaging with a complex mathematics through embodied interactions with materials, to which there is no clear or correct solution.

## Summary and Lines of Questioning

We have considered how the classes analysed brought up aspects of mathematical ideas for students in engagements with materiality, and how the potential for unexpected distortions or deformations in the mapping and monoprinting project could be capitalised on as a learning process. Mathematical ideas are only one part of the process which comes to define the final image, but their role is important and can be highlighted where it is useful to do so. The workshop we will take at Bridges should be a chance to look further into this process and think broadly on how mathematics is implicated in its various stages. We will discuss our own experiences of the materials and techniques of monoprinting, and in what ways they raise or shed light on mathematical issues. These can include proportional reasoning and mirror images, but we expect the group will open up other unforeseen avenues of thought. It will also be an opportunity to think together on ways that the tension we have identified, between the drive to be correct in the recreation of the image and the desire to express and find value in unexpected deformations, can be brought into classrooms and can be productive in the learning of mathematics.

## References

[1] Borasi, R. *Capitalizing on errors as "springboards for inquiry": A teaching experiment*. Journal for research in mathematics education, vol. 25, no. 2, 1994, pp 166 - 208.

[2] Dean, M. L. Using art media in psychotherapy: Bringing the power of creativity to practice. Routledge, 2016.

[3] Morton, L. "Imprinted: The use of simple printmaking techniques in arts therapy." *Australian and New Zealand Journal of Arts Therapy*, vol. 14, no. 1, 2019, pp. 56 - 64.

[4] Nemirovsky, R., Ferrari, G., Rasmussen, C., and Voigt, M. *Conversations with Materials and Diagrams about some of the Intricacies of Oscillatory Motion.* Digital Experiences in Mathematics Education, vol. 7 no. 1, 2021, 167-191.

[5] Nemirovsky, R., Tierney, C., and Wright, T. *Body Motion and Graphing.* Cognition and Instruction, vol. 16, no. 2, 1998, pp 119-172. https://doi.org/10.1207/s1532690xci1602_1

[6] Stiny, G. *Kindergarten grammars: designing with Froebel's building gifts.* Environment and Planning B: Planning and Design, vol. 7, no. 4, 1980, pp 409-462.

[7] Gelli Arts. *6" x 6" Gelli® Printing Plate.* https://www.gelliarts.com/collections/products/products/6-x-6-gel-printing-plate

[8] Gelli Arts. *Student Brayer.* https://www.gelliarts.com/collections/aprons-more/products/student-brayer