The Marvellous Bridging of Maths and Art Education and its Relation to Cognitive and Emotional Development

Gunnel Berlin

University of Gothenburg, Sweden; gunnel.berlin@gu.se

Abstract

The decade-long project Eureka (2002 – 2012) in primary schools sought to integrate art with other subjects, especially mathematical subjects such as numbers, basic geometry, the golden ratio, and even the Mandelbrot set. The project was initiated by Gunnel Berlin, artist and pedagogue, with the performance artist Eva Dal also participating for three of those years. We worked together with students and teachers at Åsenskolan, Kungshamn, Sweden and with other primary schools in the municipality of Sotenäs. We found that an integrated study of math and arts deepened students' understanding, creativity, knowledge, and democratic culture.

Relations Between Arts and Math

The study of shapes in art is very closely related to that of geometry in maths. When students discover visual and mathematical patterns in art, they can develop their understanding of the mathematical subjects and at the same time immerse themselves in the visual arts and its history. The decades after the discovery of the camera, artists had to change their focus from imaging nature to studying of the basic parts of our visual world, that is to say colours, shapes, movements and directions. The modernists did so, and by studying their development, students can discover not only art history but also visual mathematics. Maybe the most important thing of all: they will be responsible for their formation as democratic beings.

Eureka [1, 2] was the starting point for cognitive studies and an interdisciplinary way of working with maths through art, from addition to the Mandelbrot set [3]. Educating pupils in art can be a way not only to increase their art skills as such, but also to develop their cognitive and emotional capacities. In each artistic expression, there is a great amount of basic knowledge that is possible to teach, such as colours, shape, etc. They are veridical as their questions contain right or wrong answers. Whereas unique artistic expressions do not have this kind of answers; they are adaptive and each and every pupil has to search for a result of their own – or in relation to each other if it is a collective work. No teacher can do that job nor tell pupils how their artistic processes and results are supposed to be.

What was found at the end if the project was that the ratings in art after the ninth grade was significantly higher for the students that had participated in Eureka during primary school than the rest of the students and notably but not statistically determined in mathematics.

Veridical and Adaptive Questioning

Some parts of art education are what Goldberg [4] calls veridical in contrast to adaptive, based on tasks that the teacher has decided and also knows what the result is supposed to be. A smaller circle with two triangles on the top, placed upon a bigger one is the model for how to draw a cat. Not a special cat, but the iconic cat. In the same way, the calculation problem 6 x 4 = 24 has one right and myriad wrong answers. But if teachers work with adaptive questioning instead of veridical, the student will develop their creativity, as there are countless possibilities of making, for instance, a pattern out of two kinds of shapes as well as to find calculation problems whose answer is, e.g., 96. The child in first grade might be happy to note that 95 + 1 might work, or she might combine a pattern out of circles and triangles horizontal, one at a time. The third-grade student may answer 12 x 8 and an older student might go for the square root, etc. and perhaps then deepen their pattern to a more complicated one in two or three dimensions.

The great challenge for every teacher is to find a good balance between veridical and adaptive questioning. This balance also develops the frontal lobes of the brain. The frontal lobes used to be called "the silent lobes" as they did not seem to be related to any of the senses. But they are the ones responsible for the coordination of the brain: the conductor of the orchestra, so to speak, and not just the cognitive parts but also the emotional parts. Both are indispensable for rational thinking, according to neuroscience research. Goldberg [5] also points out patterns as a fundamental subject for human thinking and a resistance against dotage. Working with patterns is an excellent way of combining arts and maths.

To understand our external world, humans have to create inner pictures. It is a precondition to understand the structure and the existence of matter and living beings. When creating art, the pupils can investigate, give statements, do questioning, and express their own particular nature. This may give society a well-educated population, as well as creative individuals. And just like every pupil´s work of art is supposed to have its uniqueness, it constitutes an exercise for the brain as it has to decide what to do and when to stop. By engaging pupils in creative processes, they will transform their insights not only about art, but also develop an approach towards mathematics and even other subjects. The close relation between art and math strengthens, among other things, the importance of creativity in problem solving.

Inclusive Approach

By working with arts and maths closely related, we also took an inclusive approach. Some children hate art studies but love maths, others the other way around. By entering through each child's own preferred doorway, that child might discover things she or he never wanted to see or couldn't imagine. Researchers have found that students who cannot find the correct solution at math lessons can do in in other subjects [6]. Working with arts and maths united also includes newcomers with different mother tongues and facilitates the understanding of facts and notions.

Starting Points

We present six-year-old children, just starting school, with colours and shapes. By investigating chromatics, trying to discover as many nuances as possible out of the primary colours, they get the tools to distinguish and create the colours wanted. As we start with the investigations, without any concerns of the result as a "piece of art", most children get engaged and can continue for months finding out more and more. We have found out that initiating the studies of colours gives an inclusive approach, as most children are very fond of the mystery of colour mixing and keep on for hours and hours.

While investigating the chromatics, shape becomes a natural part of the painting. We proceed by entering the world of shapes, using the mathematical notions. Referring to Euclidian Geometry, we develop the different parts, starting with the single line from point A to B – which might be from one side of a paper to another. The student will figure out what kind of line it is – it might be a rocket, the wall between the kingdoms of Hades and Zeus, the horizon, etc. (Figure 1). From here we continue with the triangle, the rectangle and so on, making at least one painting for each shape.

Figure 1: *Different interpretations of the line as the starting point for a painting.*

Modern artists are important in these studies, although things have happened in art in the last 150 years. When they first see modern art, pupils often say things like: "Such a daub, smudging…" but talking about the history of art and what the artist did when the camera took over the naturalistic reproduction, they begin to understand. As all of them can make works inspired by artists such as Münter, Delaunay, Kandinsky and Klee, they'll soon become familiar with the artists and their aims as well as mathematical notions and artistic expressions (Figure 2). All lessons start or end with talks about some of the students' works.

Figure 2: *Three students' works, inspired by the artist Wassily Kandinsky.*

In preschool and first grade, the pupils often do their paintings by freehand. As they get older, they will use tools such as rulers and compasses while constructing their works. Creating shapes like the equilateral triangle includes both constructive and artistic skills (Figure 3).

Figure 3: *A third-grader observing the composition of equilateral triangles.*

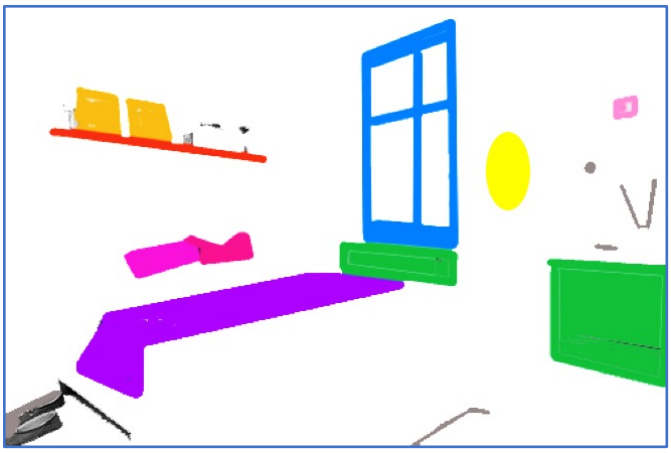

Figure 4: *The understanding of the relations between the shapes in a perspective view can be facilitated by drawing and painting on a copy of a photo.*

Perspective Shapes

When we get to the trapezoid, the parallelogram and the oval, we study their relations to rectangles and the circle. That is the key to understanding perspective in painting or photos. We talk a lot about what the brain knows and what the eye sees. Realizing this difference, the students take a photo, then, on a copy, they will paint only the shapes that reveal these changes (Figure 4). They then continue to do an abstract painting out from this sketch so that the relations become evident.

Symmetry and Patterns

When the students are familiar with colours and shapes, we enter the world of symmetry and patterns. As the outside of the human body is nearly symmetrical, we study the face and the body, do free symmetrical

paintings (Figure 5a,b) and also discuss the asymmetric notion while looking at Picasso's cubist paintings and how he strived for movement in his paintings (Figure 5c).

(a) (b) (c)

Figure 5: *First graders' paintings of symmetry (a, b) and asymmetry inspired by Picasso (c).*

Our pupils' suggestions lead us to do works from digital photos. The pupils take photos of themselves in pairs, then they (or the teacher, depending on the age), take away the left or the right of the photo and complete the drawing on their own (Figure 6).

While working with symmetry, the teacher may easily notice whether the pupils have understood the meaning of the notion "symmetry." The relation to the symmetry line will be showed in the painting and the teacher can show the pupil, for instance by using a mirror, how to make it correctly.

These tasks can constitute the entrance of the marvellous bridging between maths and art that will probably never end.

Figure 6: *A drawing made by a pupil in 2nd grade from of a photo of half her face.*

References

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