Mathematics as Aesthetic Experience: Exploring Geometry through Dance, Drawing, and Literature with Children

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Abstract

Since 2012, a research project has been conducted at the Research Laboratory on Primary Mathematics within the Department of Education at Roma Tre University, investigating the teaching and learning of mathematics in preschool and primary education through the integration of dance, music, visual arts, and picture books. The research focuses on dynamic aspects of elementary mathematics—such as iteration, ratio, motion along the number line, and the generation of lines and solids—and their connection to aesthetic experience. The program includes classroom activities for children and 16-hour professional development workshops for teachers. We propose a 90-minute session that explores the concept of the line as a trajectory through movement, drawing, and dialogue. Participants will be invited to navigate between their adult perspective and a child's experience, in order to examine how embodied, artistic practices can support the development of geometric reasoning and enhance mathematical awareness and enjoyment.

A Program for Dance and Mathematics with Children

The aim of our research is to explore connections between mathematics and the dance-movement aesthetic experience in childhood. Movement can be dance: it is therefore not only a physical act, but also the profound expression of the human imagination and inner world expressed through the body. A dynamic experience of learning mathematics could be encouraged by whole body motion, beyond the standard use of visual and tactile educational devices.

We developed a program on mathematics and dance for children in kindergarten and primary school made up of 4 itineraries targeting respectively plane geometry, natural numbers, ratio/rational numbers, and space geometry [23]. This program aims to represent an alternative to the math lesson, in which children spend most of the time sitting down silently performing computations. In each itinerary, music supports and nurtures dance, and we explore also drawing that originates from movement [1]; furthermore, picture books bring the power of words and the visual arts inside the experience [3]. We chose the term itinerary to emphasize the dimension of exploring mathematics through the arts. Rooted in the Latin *iter*, meaning path or journey, it suggests movement and discovery.

The programme for pupils was combined with 16-hour workshops for the professional development of teachers [21] interested in transversal maths-dance interaction, also involving dance-theatre training to work on self-awareness [2, 8, 22]. The core idea behind the workshop design is that it employs a selection of activities originally created for children. By participating, teachers are encouraged to step into the children's shoes, with a particular emphasis on integrating mimesis and mathematical discussion.

Such a strategy has been developed in the context of a broader project funded by the European Union (ANFoMAM from "Aprender de los niños para formar a los maestros en el área de matmáticas", which translated to english means "Learning from Children to Train Teachers in Mathematics), focused on the design of experiential math workshops for kindergarten and primary school teachers [4, 21], in which the documentation of learning and teaching processes, as well as the immersion of the researchers in the lived experience [30], played a crucial role.

Theoretical and Pedagogical Framework

The mathematical structure underlying art (poetry, visual arts, architecture, music, dance) offers the opportunity to "see" and "feel" mathematics, as Federico Enriques (1870-1943) illustrated by quoting Dante's allusion to the tension of calculation/proportion in poetry (the "fren dell'arte" in *Divina Commedia* Purgatory, chant 33, Enriques in his 1938 essay *Mathematics in History and Culture*, in Italian).

Conversely, the mathematics underlying arts contributes to the aesthetic experience as an inner resonance that leads to awareness of otherwise invisible aspects [5] (note that the ancient Greek *aisthētikós*, "perceptive, sensitive, pertaining to sensory perception" comes from the verb *aisthánomai*, "I perceive, sense, learn").

The cognitive power of aesthetic enjoyment of the artworks is deeply linked to mimesis, as described by Aristotle: a human disposition connected both to the arts and to the understanding of the world, since childhood. Mimesis does not mean just external imitation, but involves one's own interiority by becoming someone/something else, grasping its essence. Kieran Egan highlights the importance of pre-linguistic somatic understanding (grounded in bodily experiences) from early ages [10], and Gilberto Scaramuzzo advocates for integrating mimetic experiences into educational contexts [26]. Children's play typically involves becoming things/people-in-action, as-similating them, as a somatic, mimetic movement.

It is often considered that the first steps in mathematics during childhood consist of a hard struggle towards abstraction as part of the detachment from the immediacy of experience towards conceptual understanding [7]. Yet mimesis, imagination, and counterfactual thinking [15] can strongly support the child's initiation to mathematical concepts by the natural movement towards seeing the invisible in the visible and creating other "worlds": "children's imagination is the most powerful and energetic learning tool" [9, p. 2]. Édouard Séguin (1812-1880) developed exercises with solid forms (bricks, rods) for children with intellectual disabilities taking advantage of mimesis, a potent inner human energy supporting consciousness, in the discovery of the "not me" [14].

The activities are inspired by the educational implications of dance as outlined in Rudolf Laban's work [19], and the entire planning is based on the belief that dance can offer a foundational experience for approaching mathematics in a different way, as suggested by the research of Karl Shaffer and Erik Stern, who have long worked to highlight this connection [27]. Dance, in fact, historically embodied principles of geometry and arithmetic—from prehistoric ritual patterns, to the codified spatial structures of Renaissance and Baroque choreography, and up to ballet and the diverse, multifaceted expressions of contemporary dance [28]. The rhythm of bodily movement is provided by music—it shapes what we hear [6]. The dancer moves through space, envisioning an inner plastic dimension: tracing lines, crossing or resting on planes, and forming regular or irregular shapes [19]. In this way, the dancer creates a true graphic, pictorial, and sculptural composition through an instant choreography that guides the body in space. In contemporary dance training, imagination is increasingly emphasized to enhance spatial awareness and movement quality [24].

Dancing activities involve children being both dancers and spectators and experiencing the joy of movement and living beauty, connecting imagination and mimesis (see below some hints on the educational methodology of our program). Dance encompasses the power of mimesis and the early aesthetic experiences; it offers rich opportunities for sensory and fully embodied engagement with mathematical ideas and it can be a kinesthetic, embodied way of mathematics learning [13].

Starting from this experience in motion, it is possible to explore the speculative aspects both related to the experience and the concepts that emerged, trusting in children's capacity for reasoning and argumentation [15], with a vision of mathematics as a possibility for human flourishing [29] and for the personal growth of children as whole individuals.

The Session: General Description

Our goal is to share with participants such an educational program, in which dance and mathematics are in constant cross-curricular dialogue supporting artistic esthetical as well as mathematical speculative understanding and experiences. The session offers a sample of activities regarding the first itinerary in the program (see above), devoted to the line as trajectory and aimed especially at children in kindergarten and the early years of primary school [23]. While exploration the generation of lines in the plane, it also targets handwriting as a gesture by linking drawing, motion and geometry. As in the workshop for professional development, adult participants are invited to experience activities originally designed for children

The session focuses on the aesthetic experience of primordial geometrical conceptions: plane, point, (straight) line, angle, distance, parallelism, intersection, on, betweenness, and congruence [16]. Some of them are considered "basic" since they are primitive (undefined) objects or relationships in the classical axiomatic conceptualization of Euclidean geometry [16]. Moreover, those are primordial concepts in the "making of the human mind" following recent studies in cognitive archeology [25]. The overall experiential path is intended to gradually unravel the geometrical content, through the two components of music and choreography. Targeted geometric conceptions—traced with the whole body on the floor, within the room, and with the hand dancing through space—connect to the primordial experience of marking, akin to the non-figurative markings found in Paleolithic cave art [17, 18].

The approach follows – as in a parallel plane – the educational methodology singled out for children, based on three pillars: a) exploiting mimesis-somatic understanding, b) combining in-motion/listening whole body experience with sitting down graphical work (thus linking 2D and 3D), and c) math talk on the shared lived experience conveying word expression. The experience is a collective process led by a single person—the instructor or 'teacher'—and combines dance-movement activities, paper-based tasks, and moments of discussion and reflection on shared experiences. For adult participants – as it is in the source activities addressed to children – graphical work helps to increasingly leaving in the foreground the body experience and sensations of "the real world" and thus reinforces the conceptualization and symbolic aspects of mathematics, extending to primary school the considerations in [12, p. 54].

Table 1: *Session's Schedule.*

Phase I: Inside one's body, inside movement	1) Opening ritual 2) Energetic warm-up 3) Blowing on the body	20 minutes
Phase II: From space to the paper and back	4) Tracing with the whole body: a brush painting in the air 5) Graphic representation of the lived experience 6) Reading a story: dance and paint with "Red line, blue line" 7) Cool down	40 minutes
Phase III: Discussion and reflection	8) Conversation/active reflection on the math topics	20 minutes
Phase IV: Writing	9) Diary	10 minutes

Description of the Session

Phase I: Inside One's Body, Inside Movement

At the beginning of the session, activities are proposed that lead participants into the present context of experience, to be fully present in the moment, both physically and mentally. Exercises build awareness,

so as to be open and confident to engage in an unknown "space". Attention and concentration need initial support for the aesthetic experience to be fully enjoyed.

Opening ritual (*5 minutes)*

The room has been prepared by marking several points on the floor with tape, forming a circle to indicate where participants should stand. The teacher asks everyone to step outside the room and line up in front of the door. Using a touch, a sound, or another sign, the teacher invites them to enter the space and place themselves on the marked points. Music is already playing in the room. The teacher emphasizes that they are stepping into a space filled with music and sound, an environment where they can let their bodies play and move freely without words, communicating solely through movement.

Music: Beach House, *Myth* (from the album "Bloom")

Energetic warm-up (5 *minutes*)

The teacher arranges the participants in a circle and leads an energetic warm-up that follow the imagery of "taking a shower", beginning at the head and gently tapping down to the toes with fingertips. The teacher encourages everyone to imitate his/her actions, she/he reminds participants to keep their fingers and hands soft and relaxed. The sequence is then repeated using gentle fists, followed by a mindful massage of each body part. The warm-up concludes with a deep inhalation, bringing the hands to the top of the head, and an exhalation, tracing a smooth, continuous stroke from head to toe.

Figure 1*: Breathing exercise, training course with teachers in service, state primary school Don Andrea Santoro (Priverno, Italy), 2018*

Blowing on the body (10 minutes)

In this exercise blowing is engaged to perceive the impulse and the direction of movement. The teacher forms pairs. Taking turns, one person gently blows on five different points of their partner's body while the other keeps their eyes closed. Then, they switch roles. Next, the teacher invites the pairs to move around the space. One person in each pair chooses a position and remains still with eyes closed. Their partner then guides them by softly blowing on different parts of their body, encouraging them to move in response. The movement should allow body parts to follow or create imaginary lines in space or on the floor. The teacher emphasizes that the exercise is to be performed with great care and gentleness, avoiding any pulling or pushing. Instead, the focus should be on helping the partner explore movement organically. It is also essential for participants to imagine the direction their body takes in space as it follows the impulse of the blowing. Finally, partners switch roles.

Music: Air, *Ce matin-là* (from the album "Moon Safari"); Beach House, *Myth* (from the album "Bloom").

Phase II: From Space to the Paper and Back

Tracing with the whole body: a brush painting in the air (15 minutes)

The teacher explains the exercise: participants move freely through the space, filling all empty areas. The teacher then calls out different body parts, instructing participants to initiate movement from the specified part. They should imagine that this part is being "moved" by the blow from the previous exercise and that it acts as a brush, painting in the air. Initially, they will be asked to paint on the ceiling, walls, or floor. Gradually, they will be encouraged to imagine and explore other planes where they can draw. After allowing enough time for exploration, the teacher will introduce the concept of drawing lines evolving without changing directions. Throughout the exercise, the teacher will pause the music at irregular intervals. When the music stops, participants must mark an imagery point in space and fix it on their chosen reference plane. When the music resumes, they will change the direction of their movement, beginning from the marked point. The teacher will demonstrate this part of the exercise.

Body parts used in the exercise: head, arms, elbows, shoulders, legs, and feet. Each body part is associated with a specific song to guide movement: Zap Mama, *Take me coco* (movement starts from the head); Roberto Emilio Goyeneche, *Ventanida Florida* (movement starts from the arms, elbows, and shoulders); Otis Redding, *Sittin' on the Dock of the Bay* (movement starts from the feet and legs). Since initiating movement from the feet and legs is often more challenging, the teacher may allow extended exploration time with the other body parts. This ensures that participants fully engage in the aesthetic experience that connects movement, imagination, and line drawing.

Graphic representation of the lived experience (5 minutes)

The teacher arranges participants in a circle and distributes large white paper sheets (A3) with wax crayons, pastels, and thick markers. The teacher asks participants to close their eyes and recall what they drew in the air and/or on the floor. The participants are asked to represent the lived experience of drawing points and straight lines they created with their body parts in the previous activity.

Figure 2*: From three-dimensional to two-dimensional; a girl representing her drawing in motion on the floor, state primary school Sandro Onofri (Rome, Italy), 2017*

Reading a story: dance and paint with "Red line, blue line" (15 minutes)

The teacher divides the participants into two groups. One group will listen to the story read by the teacher and, while listening, they will move freely in the space, following and recreating with their bodies the events of the two protagonists: two lines or shapes of different colors (Susanna Mattiangeli – Alice Beniero, *Red Line, Blue Line*, Publisher: Academia Universa Press, 2017). The other group is divided into pairs. Each

pair receives two markers (one blue and one red). The teacher asks them to place two sheets of paper side by side. As the teacher reads the story, the participants will draw on the paper, visually interpreting what they hear.

Figure 3: *A group of children working on "Red line, blue line", State primary school Via Ceneda (Rome, Italy), 2019*

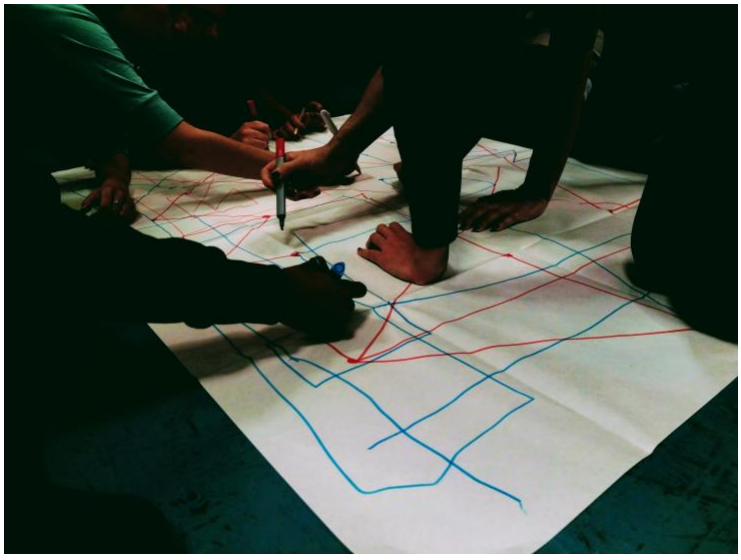

Figure 4: *Students and teachers working on "Red line, blue line", Post-graduate educational course in Pedagogy of Expression, Roma Tre University (Rome Italy) a.y. 2017-2018*

Cool down (5 minutes)

The teacher gently guides the people into a seated circle then invites them to close their eyes and focus on their breath. The teacher leads them through ten slow, deep breaths, creating a calm and peaceful atmosphere. After the breathing exercise, the teacher asks everyone to bring their hands together. They softly count to three, signaling them to open their eyes. As they do, they gently blow on their fingertips and clap their hands three times in unison, simply following the teacher's lead.

Phase III: Discussion and Reflection

Conversation/active reflection on the math topics (20 minutes)

The teacher asks the group to divide into pairs and gives each pair five minutes to analyse the graphic works using a set of guiding questions. Each pair takes notes on three separate sheets of paper, noting what they observe in the artwork, identifying at least three geometric objects or conceptions present, and writing three words that summarize their experience.

Once the time is up, the teacher invites the pairs to paste their responses onto a large sheet of paper placed on the floor. This sheet is divided into two halves: one side is reserved for responses related to the lived experience, while the other side is dedicated to mathematical conceptions.

The teacher then encourages the group to observe the overall composition and reflect on how the activity might be further developed or adapted for secondary school students (Grades 6–12) or for a general adult audience.

Phase IV: Writing

Diary (10 minutes)

At the end of the session, the teacher emphasizes the importance of taking time to write a diary about the experience, focusing on their personal reflections, including the connections between different languages and forms of art, and the mathematical themes that emerged.

Final Remarks

The session's goal is to "experientially" convey the idea that pleasure and imagination, trained through dance, enable children to access "demanding" mathematical concepts that are often considered too abstract to be understood in childhood. Mathematical education in primary school can be also carried out by immersing oneself in perceptual aesthetic experience (dance, music, and visual arts), decoding its meaning and processing it (representation; narrative memories; connection to math exercises with number, figures, measure, and so on). Mathematics and art, which are often seen as opposite (the realm of rationality against the realm of beauty and feeling), arise from a common root: the exploration of the invisible. Through dance, mimesis can be put to play with primordial mathematical concepts, evoking the ancient experiences of body motion and material engagement, in time and space, that originally begot them. Reciprocally, in dance, there is a tendency to organize and think about the aesthetic experience in mathematical terms [19, 24], which does not limit self-expression but rather supports it: the arithmetical and geometrical concepts that modern *choreutics* [20] has unveiled, enrich the pupils' conscious expression in action.

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