Letting Art Teach Aesthetics, Math and Language

Paul Moerman

Culture and Education, Södertörn University, Stockholm, Sweden
Art Education, University of Jyväskylä, Finland; paul.moerman@sh.se

Abstract

This papers presents a practical work model as well as an educational theory discussion on the status and potential of art work in teaching and learning math in early childhood education. The central idea is to let the child's free creative art activity reveal, or "teach", whatever mathematical thinking was inherent in the creative process. Paying careful attention to art and math adequate language in "meta talks" with children about their art work, is found to be a rich tool in enhancing the young learner's development of aesthetic, numeric and linguistic literacies in gainful interplay. A field study in preschool teacher education is reviewed, including a mapping of Alan Bishop's [2] mathematical activities in doing art work, and an interpretation of the work model in line with John Dewey's [5] and Gert Biesta's [1] thinking on art as experience and art as education.

Background

The context of this paper is a course in preschool teacher education at Södertörn University, Math Didactic Activity in Preschool, formerly Children's Mathematical Thinking and Problem Solving. On a theoretical note concerning early childhood education, arguably adaptable also to other school levels, the aim of the paper is to cater for artistic activity in teaching and learning at large, and, in this setting, for a blunt approach to let art (work) teach math altogether. The aim of the paper is to present ways of interlinking art and math in education as modes of knowledge, and as modes of being in the world. The case study reviewed below exemplifies the status of art in education in Swedish curricula and syllabi. The study took place during the Spring and Fall terms of 2019. A total of 162 preservice teachers participated, and practiced the model presented with pre-school children age two to five.

My commitment as dancer and teacher educator in various math courses is to define, prepare, carry out, assign and assess "aesthetic" activity in teaching and learning. Previous encounters with the involved teacher students include courses such as Math in Early Childhood Education and Math and Math Didactics, where I applied parts of my teaching and learning program *Dancing Math* [8], featuring designed dance activities, in which specific math curriculum content is discerned, discussed and formalized in equations and figures as found in regular text books.

In the course discussed here, I opted to establish a link to a previous course focusing on proficiencies in the arts as subjects in their own right, dance, drama, music and visual art, and let the art work disclose, i.e. "teach" whatever mathematical thinking was implicit in the creative processes. The works were revisited in talks, first on the aesthetic, then scrutinized with "math specs". My intention was to bring aesthetic, linguistic and numerical literacies to the fore as competitive but interplaying proficiencies.

Course syllabus content and implementation strategy

The course syllabus of Math Didactic Activity/Children's Mathematical Thinking and Problem Solving stresses the significance of language and conversation in elucidating children's mathematical thinking; hence I introduced "meta talks" as awareness building action. Understanding children's mathematical development, including children's math learning in informal settings, must build on existing math didactic theory, which I here chose to exemplify by reading the creative processes in the arts in terms of Bishop's [2] categories of mathematical activity. Simultaneously, leaning on Biesta's [1] thinking on art as teaching, I sought to underline how individuals, including children, "do" math while creating art. Reflective talks on

how they reasoned in the course of their art work, can aid children to realize they were engaged in mathematical problem solving, which is a way to let the art teach them math. At the same time, while discussing, they develop specific language skills to express both the aesthetic and the mathematical.

The work model presented below aims at fulfilling additional learning goals in the syllabus, such as the ability to plan, carry through and assess teaching modes enhancing children's mathematical development, to discuss the relation between math content and literacy development, and to apply and motivate teaching and learning through the arts in math didactics.

My overall ambition and strategy is to promote teaching dance, drama, music and visual art, thus enhancing children's aesthetic development on the one hand, and elucidating children's mathematical thinking an adherent language development on the other hand.

A further commitment is to give body and substance to a number of teaching goals concerning the arts, math and language, stated in the Swedish national curriculum for the preschool [11]: to provide conditions for children to develop an ability to create, express and communicate occurrences, thoughts and experiences in different forms of expression such as image, form, drama, movement, singing, music and dance, to develop an interest in stories, pictures and texts in different media, as well as the ability to use, interpret, question and discuss them, to develop a nuanced use of spoken language and vocabulary, to relate things, express thoughts, ask questions, put forward arguments and communicate with others in different contexts, to develop an ability to use mathematics to investigate, reflect on and try out different solutions to problems, to develop an understanding of space, time and form, basic properties of sets, patterns, quantities, order, numbers, measurement and change, to reason mathematically about this, and to develop an ability to discern, express, investigate and use mathematical concepts and their interrelationships.

In conclusion, the design of my contribution to the course, reading the learning goals both in the national curriculum and the course syllabus, zooms in on the gainful interplay of aesthetic, linguistic and numerical literacies. My commitment, as dancer and as pedagogue, is to advocate the integration of the child's work in the arts in early childhood education generally, and to jointly address the child's aesthetic, language and mathematical development particularly.

Theoretical background

The broader perspective in educational theory, propounded by Biesta [1], is that art and education can be viewed as similar activities: the artist, like the pedagogue, *shows* us, points out and helps us to discriminate something that might be important, worthwhile and meaningful to pay attention to. Biesta elaborates on this argument in terms of how the individual, dealing with resistance while working in various modes of art, is offered a chance to enter into a dialogue with the social and material world, and to become as subject, in a "mature" way – i.e., not trying to be in the center of the world, but asking what the world might expect of one [1]. In this course setting, the art work, looked at with math spectacles, discloses rich layers of inherent mathematical thinking and problem solving, and talks back to the maker, pointing out those proficiencies.

In terms of teaching and learning math specifically, the processes of doing art work may at the same time be understood as mathematical activities, described by Bishop [2]. The author discerns six categories of "universal" activity, performed in various cultures, as common, social and cultural ways of developing mathematical action and thinking: Explanation and argument, design of shapes and patterns, location and spatial perception, measurement, counting, and play [2]. The latter activity holds elements of imagining – which is at the basis of the capacity of hypothetical and abstract thinking – as well as prediction as guessing, estimation and assuming, exploration of numbers, forms and positions, and adjacent argumentation [2]. The six categories of mathematical activity will be further exemplified in the analysis of the art work below.

One link between the two theoretical lines of reasoning, on education and on learning math, particularly valuable in early childhood education, is that play, whether or not mathematical action, always holds a social, a cultural and an imaginative aspect. As children engage in playing, fantasizing and arguing, they probe and learn what it is to be in the world, socially and materially.

Work Model

One of the above mentioned previous courses, Math in Early Childhood Education, focused on designed dance activities, originally conceived for creative dance as such, now adapted to visualize children's – and preservice teachers' – pre-knowledge and conceptualizations of elementary mathematical notions and axioms, arithmetic operations, geometry, etc. While dancing, a *Space of learning* according to Marton et al. [7] was established, a space where the learning of both dance and math was made possible [9].

In this course, the approach was turned the other way round, starting from free creative work in dance, drama, music or visual art. Subsequently, the participants were guided in discerning whatever mathematical thinking and problem solving had been part of the creative processes.

In the first seminar of three, a work model was established, revisiting the students' earlier works in the arts. A selection of dances, songs and music work, drama scenes and visual artwork, performed by the students in the previous course Aesthetic Skills, were recreated. Then, possible questions were discussed to structure meta talks, a didactic approach aimed at helping children become aware of aesthetic and mathematical aspects of working in the arts [4, 6, 10]. The pedagogical aim of meta talks is to help children put words to activities done, and thus become conscious of new knowledge and skills they acquired in the process. First, aesthetic language is used in referring to the art work, describing how the dances, the drama scenes, the music and the singing were composed and performed, or how the visual artifacts were conceived and displayed. In the same fashion, math language was used to discuss and inventory aspects of mathematical thinking and problem solving, inherent in the making of the art work. The instruction outline is similar to the *Dancing Math* program applied in the course Math in Early Childhood Education, following a three-stage rocket sequence dancing-verbalizing-formalizing math [8, 9].

During the second seminar, student groups within the different art disciplines made a pedagogical documentation of their visual art work, music, drama and dance respectively. The material was photographed, filmed with digital media or documented otherwise. A structure for meta talks was set up, with possible open and directed questions to ask children, and a repertoire of terms and linguistic figures to help children put words on their aesthetic and their mathematical doing and thinking. Comprehensive lists were assembled with all possible math content that could be inventoried within Bishop's [2] mathematical activities. Upon completing the documentation work, a discussion took place on the status of dance, drama, music and visual art as creative action in education generally, and to which extent working in the arts can "teach" us a subject such as math – i.e. how art can help us perceive and sensuously experience mathematical aspects of creative art work.

The preservice teachers then implemented the model in their various working places and training placements with groups of children. The assignment was to come back to the third and final seminar with documentation and transcripts from meta talks, the children's utterances inventoried and listed according to the category of Bishop's [2] mathematical activity the quotes mirrored.

Meta Talks

Meta talks are a pedagogical tool if structured as such, with analysis and interpretation of children's questions, reflections, observations and statements. In structured talks, children are invited to speak, reflect and reason, in order to enhance their learning [3, 4, 10] – to think about their thinking [6]. Questions may be open, or leading. Open questions trigger children to start off commenting and discussing. Leading questions may ensue in guessing or unreflecting answers, but are useful in tutoring and in limiting content, calling for attention on the subject at hand [3]. In the examples reviewed below, children engaged both in counting and in discussing modes of counting, and in categorizing as to geometric *shapes*, *size* and *color*. Observant of the children's comments on the art work, the pedagogue, in turn, can guide them further, and reflect on the construction of patterns, on regularities such as *lighter and lighter*, on geometric shapes such as *circles, squares* and *rectangles,* and how these relate as parts into a whole – a flower, a boll, a sun, all examples of Bishop's [2] "universal" mathematical activities. The children's remarks allow to further

deepen into math content, handling notions such as *center*, *area*, *radius* and *perimeter*, in quotes such as: *The earth: in the middle there is a pit*, or comparing and seeing differences in *size*: *Slim trees, thick trees,* or elaborate on perspective, distance, spatial awareness in remarks such as: *It looks as if they stand in a row; they are darker in the front and it's lighter behind*, etc.

Examples and analysis

Below, a sample of fallouts from the introduction of the work model to preschool children are reviewed, in three art forms, with excerpts from the students' presentations at the final seminars. The children's utterances were listed as indications of engagement in any respective category of Bishop's [2] mathematical activities.

Visual art

In these examples, students showed the children collages they had made in the earlier Aesthetic Skills course, as an introduction to the art-and-math activity with the children, and as inspiration for the children's own creative work. Talks were initiated with open questions. All children's quotes in italic.

What do you see in the picture?

A turd.
A little pumpkin.
You can eat pumpkins and light a candle inside.
Orange. White. Red.
Green. Blue. Yellow.
The pumpkin is in the middle.
The pumpkin is up a bit.
It's a big picture.

Math aspects slip in, besides "*middle*", "*up*", "*big*":

A green rectangle.
Two triangles.

What do you see in the image?
Looks like a fruit ship.
Look, the sun is shining and it's round and yellow.
Lots of circles, the orange ones are big. Looks like oranges.
Look, the blue ones are so tiny, maybe blueberries.
Noooo, I think grapes!
I see a banana, it's yellow, it's a little longer.
There are sticks too they are very long. The sun has small sticks but they must be rays … what are rays?
And clouds. Like buns. Maybe there will be rain.

Spontaneous comments on the aesthetic:

A tree glued together.
Out of pieces.
Out of colors.
It doesn't look like paint.
It's called collage.
Lots of shapes.
Lots of colors. Black dots.
Dot, dot, dot.
Is this a blue tree?
The tree must wear its blue winter coat.

Seamless transfer to math language:

It feels like I'm in a shape land ...

Inspired by the images and the chats, the children went on to make their own collages. Many decided to depict plants and trees. While creating and commenting, the children's actions and statements were inventoried and grouped relative to the displayed mathematical action and thinking according to Bishop [2].

In the category explanation and argument, the children first described the bigger idea behind the collage and the pieces. The argued for the art work, capturing a sense of feeling for the picture in words, often putting a color to a feeling, or reasoning in comparisons: *It's warm and cold, I think it's actually both, mixed together. Ice hockey is cold, football is warm.* Factual observations were colored with affection: *It's a sun, it makes me glad. I see the view from the trees. It makes me glad how it all fits together, it's nice all together. I almost cry 'cause it's so pretty.* Colors were associated with affection and mood: *Grey like rain. I feel grey. I feel black and grey, sad. Not happy. I feel nothing. A stone … I love playing hide-and-seek.*

Further explaining, arguing and comparing, the children inserted math aspects in their reasoning: *These are little flowers, I can paint big ones. Actually, I was going to do seven heavens but I only got room for four. There are so many rectangles. I tried to make a triangle but I couldn't make one.* Some link to their home environments: *My favorite flower is yellow, they grow in my home, they are really tiny, but you know, sunflowers are huge and they are yellow too ... I love to be in the lake, but it's very deep, awfully deep but you need to wear a life vest.* It may be noted that, as numbers and spatial dimensions are injected in the arguments, overlapping between categories of math activities is common and natural [2].

In the category design of shapes and patterns, the children conceived their work of art out of their own visions. They cut the shapes of the pieces, recognized and shaped geometrical forms, and created patterns while building trunks, branches and foliage. *It's like kind of round down here and a little more square up here. Actually, it looks like a sunflower for bees. Now it's my turn to make a shape! A ball. A rainbow. A sun. A big round pizza.*

As to the activity measuring, a sorting was done according to size, by checking how big or small the pieces needed to be, or by comparing the size of plants with trees. Scaling was expressed: *What is in the picture is smaller than for real. Big bits and small bits.* Comparison occurred again: *Split in half. Double it up. I do the same. I do different. A long snake and a short one. It looks lighter, lighter and lighter. Night, day, life.*

Within the category location and spatial perception, choices were done for disposition and layout: *The pieces need to get room. The trees look like they are behind each other. Looks like … when we go in a line one after one.* When a picture was turned upside down, the children could observe more geometrical shapes, or got a sense of perspective: *I look at it from above. From the side. Look, up here and down there. Two by two in pairs.* New connotations were introduced by the preservice teachers: *What is swimmetry ..?*

In the counting category, quantifying and numbering were expressed: *Some trees are small, others are thick. One two three four five and many flowers. One, two, three leaves. I can count to ten. There's one leek, two onions and three flowers. Two triangles. Only one green rectangle.*

The play category was not dealt with in the sense of rule-bound games or competition [2]. However, throughout all the above described activities, there were elements of puzzling and, above all, imagined reality and plenty of creative argument for the shapes, the living things, occurrences and the universes created.

Song

Students who sang with the children worked with vocals, clapping and rhythmical movement. As recordings were discussed, different mathematical activities could be observed and classified. Additionally, the preservice students linked their observations to literature on teaching music for young children.

In explanation and argument, the structure of a song was discussed as it emerged in verses, refrains, an intro, a sudden stop. The content of the lyrics was commented and argued whether plausible, recognizable and related to everyday life, events and anecdotes.

As to sorting, hearing patterns was presented as a way of creating order and structure [7], as well as a support in memorizing a song. Clapping gave the children a chance to discern rhythms as patterns, and sort out similarities, such as repetitions, or differences, such as sudden stops. Claps, steps and other corporal moves to the song was a mode of embodying patterns. Clapping wrong revealed an immediate fall out of

the beat, clapping right was sensed as smoothly following the beat. It helped the children sorting out how many claps at the time occurred in the song, hearing sets, similarities and differences. Simple, directed questions helped focus on what kind of sorting and classifying was going on: *How many children are there? How many teachers? Can we clap louder? What if we sing and clap faster?* The children broadened their understanding of patterns beyond stripes and dots on a paper or a fabric, or sticks and cones in the park or the woods.

Measuring, for preschool kids, is not primarily about handling various measuring tools, but about discovering and understanding the very idea behind measuring [7]. *When we clap faster, and then slower, which way takes more time – which speed?*

In the counting category of mathematical activity, questions aiming at differentiation and synthetizing clarified conceptions of numbers, numeric skills and assessment of sets [3]: *There were eight of us singing. How many were clapping? All of us were! How many fingers were involved all together? Lots! How many times did we clap at every beat – listen ... Four! How many times did we beat on our heads? Four times! On our chests? Four times! On our knees? Eight times on the knees. Eight times standing. Eight times sitting down, legs crossed.*

In the location category, spatial perception came out of an awareness of positions and directions of the body and in the room: *We clapped when we were down on our knees. And on our heads. We stood in a circle. We stood around the drum in the middle. We sat in a half-circle. We were standing in line behind each other.*

Dance

Two students showed children pictures of butterflies and grasshoppers before exploring the insects' patterns of movement in creative dance, varying motion in space, time, force and body. The dance movements were documented, in video and drawings, including sketches of the "small creeping things" themselves. Forms were discussed, and patterns, as displayed in the insects. Other students had a session of free, improvising dance, in a similar fashion exploring the basic elements of movement: space, time, force and body parts involved. The dances were documented, filmed and discussed. The students' observations, tied to literature references, and the children's comments and mathematical thinking, were listed according to Bishop's [2] categories.

In explanation and argument, questions came up such as: *How much can a butterfly spread out in space?* Some children "flew" all around in the air, applying spacious movement. One child sat still on the floor: *I only move my wings, I can spread them, and flap them on the spot. How high can a grasshopper jump?* The children explored different ways of jumping, scampering back and forth in different directions, tempi and heights. *My grasshopper leaps both feet together. Mine is on all fours. How low can a grasshopper hop?* Children crouched and hopped on all fours, some lay down on the floor: *It's tired. I need to take a rest, over here*. Again, aspects of counting, measuring and location melted into the argumentation.

Sorting and seeing patterns evolved as one child observed the butterfly's symmetrical shape, and explained in the most self-evident of fashions: *Everything is the same on this side and on this side of "the middle body"...*

Measuring was done as children asserted the total of the moving bodies, and how they assembled and dissociated in different phases of the dancing. *There was one left over. We were one short.*

As to counting, numeric ability is about discerning number, sets, scope and changes [3]. The children worded order: *A. moved as number one, E. as number two, J. as three and L. as four.* Movement was literally translated in math terms: *We met in pairs. Two pairs became four.* Open questions asked were: *How many steps do you think we took in the dance all in all?* Attention was brought to the principle of random order: *Does the number of dancers change as they move away from each other or close in? No!*

As to the location category, children may experience spatial concepts if they have a chance to meet comparable objects, estimate distance, angles, which are capacities they can develop only while corporally

exploring space, area and levels [7]. Here, the description of the mere dance movement melted together with the expression of the mathematical activity: *We danced tight together on a little spot on the floor, closer and closer to each other. We moved all around the room. We were in the middle of the room. We danced high up in the air. We reached to the ceiling.*

Similar to their singing comrades, the dancing children displayed spatial awareness in positions and movements across the floor, which they worded as: *We skipped round, round in a circle. We made a square the four of us. We sneaked behind each other.* Open questions drew attention to directions, visualized by the dancers: *Where was everyone dancing?* Or leading questions: *Where was L. off to? Did J. and E. dance low to the floor, high up in the air? L. and E. danced to the same side. I stood in the front, you were in the back. Them two were in the middle.*

Tentative Conclusions

Creative work in the arts is a playful and fun pedagogical pursuit, revealing, on reflection and discussion, both artistic thinking and plenty of mathematical thinking and problem solving. The above mapping according to Bishop's [2] categories of mathematical activity emphatically reveals a variety of math content and concepts dealt with. The children's descriptions, comments and explanations deepen into the artistic and the mathematical, while continuously expanding adequate vocabulary, stylistic means and other linguistic tools to capture knowledge and skills in both subject areas. Further study might need to deepen into art mode specific features in the math thinking and problem solving disclosed, as "the arts" are essentially different disciplines, modes of knowledge and ways of being in the world.

We all handle math notions and principles daily, in order to understand and cope with everyday life [3]. Also children do sort, classify and organize, in order to understand interconnections in their environment and to carry through such activities as doing a jigsaw puzzle, building a tower or making a drawing, play activities in which they carry through math procedures, but they might need help to put it all into words in order to more aptly think math – which is where the pedagogue can guide the youngest in exploring the surrounding world through "math glasses" [3].

Play is the preschool child's principal agent in developing, learning and becoming as subject in the world. The presented work model offers the pedagogue and the child a vivid forum for reflection on various aspects of any play activity, and together point at all the fun and wonder it holds, the invention and the interaction, the artistic and the math, otherwise so abstract and invisible, now emerging as concrete concepts the child obviously is gaining mastery of.

Educational Stance on Art, Math and Language

The set up described is presented as an alternative math teaching and learning strategy for the youngest, e.g. to the tradition of finger counting in learning numbers and quantities, or to technical exercises. The main object is to create means for the children to experience mathematical thinking as perception and cognition in interaction. To Dewey [5], the sensuous, the cognitive and the emotional are all part of the doing and undergoing constituting the *aesthetic experience* [5], the work of the senses and the mind – *minding*: paying attention to the object of the experience, the art work, and all there is to pay attention to, including math facets.

Internalizing math notions, concepts and mathematical thinking evolve through a process of meaning making. Children in the examples above make links to their home environments. They relate their doings here and now to earlier experience. They add flavor and color to the new experience, the interaction between the self and the surrounding world, leading to new meaning, knowledge, proficiencies and insights.

Math is all around us, all around the children. Math may be abstract, some may hold math is not of the perceptual world. Yet, mathematical notions describe largely measurable relationships between phenomena and occurrences in terms of space, time and quantities, which we all can experience with our senses [3].

Aesthetic activity, doing art work, provides such spaces for sensuous experience and exploration of otherwise abstract knowledge content.

Biesta [1] suggests we look at art and education as similar activities, the artist's and the pedagogue's archetypical gesture being to *show*, to point out and invite us to pay attention to something possibly important, worthwhile and meaningful attending to – an invitation to the world of sense-making. Engaging in artistic activity, Biesta [1] means, provides spaces for the work of the hand, the head and the heart, turning our senses towards the world, to find out what the world might offer us, and expect of us – a call more urgent than ever.

Doing art with the youngest and engaging in sensitive meta talks, helps us notice and sense all there is to perceive, and put it into words. Math thinking and problem solving are revealed, in a simultaneous process enhancing subject adequate vocabulary. Opportunities are offered to experience and talk about the art work as both art and math activity – opportunities to let the art work teach us math and language.

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