



Geometry in Art? Scenes of a Colonisation of the Look and the Thinking in Mathematics Education

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Received for publication 29 Apr. 2022. Accepted after review 13 Dec. 2022
Designated editor: Maria Célia Leme da Silva

ABSTRACT

Background: Wouldn't the transformations of artworks over time be the most convincing record of how geometry was historically practised and transformed? Now, it seems that research on geometry, whether as a theory or a school subject, leads us to a no less important problem linked to its effects and modulations on subjectivity. In mathematics education, one sees the agency of art for a very specific purpose: learning geometry through art. However, geometry is not just a set of theorems, concepts, and forms to be apprehended; it is also a *device* that, imprinted on our thinking, makes us talk about the world and its things. That is, it participates in the game of relations of power, knowledge, being, life, and nature, producing truths reiterated and subordinated by the ways of looking, thinking, and representing. **Objectives:** This article aims to analyse aspects of the relationship between geometry and art that put into practice a colonial *matrix of power* in mathematics education. **Design:** To do so, some scenes are presented, such as *body-scene*, *space-scene*, and *nature-scene*, considering geometry and art in its historical and educational forms. **Setting and Participants:** It is supported by art, art history, and research that articulates art and geometry. **Data collection and analysis:** Examples of the use of geometry in art are raised, analysing, through *visuality*, the functioning of a practice that produces and reproduces the presence and effects of the coloniality of power, knowledge, and being. **Results:** A geometrised fictional reality is revealed and conditioned by the ways of looking, thinking, and representing, in which geometry, operated with art, conforms and puts into practice a colonial thought, fostering the destabilisation of power and knowledge relations. **Conclusions:** Finally, the question is: Are we creating, in our educational practices, possibilities of deterritorialisations, lines of flight, decoloniality, to venture with other attitudes within the disciplinary devices in mathematics education? Therefore, it is necessary to think more about the truths put forward than to affirm them: for a new ethical, aesthetic, and political *ethos* in mathematics education.

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Keywords: Teaching geometry; Coloniality; Decoloniality; Mathematics and art.

Geometria na arte? Cenas de uma colonização do olhar e do pensar em educação matemática

RESUMO

Contexto: As transformações das obras de arte, ao longo do tempo, não seriam o registro mais convincente de como a geometria foi praticada e transformada historicamente? Ora, parece-nos que a pesquisa sobre geometria, seja como teoria ou disciplina escolar, leva a uma problemática, não menos importante, que é aquela ligada aos seus efeitos e modulações na subjetividade. Na educação matemática vê-se o agenciamento da arte para um fim bem específico: o de aprender geometria pela arte. Entretanto, a geometria não é tão somente conjunto de teoremas, conceitos e formas a serem apreendidos, ela é também um *dispositivo* que, impresso em nosso pensamento, nos faz falar do mundo e das coisas que nele estão, isto é, participa do jogo das relações de poder, de saber, de ser, da vida e da natureza, produzindo verdades que são reiteradas e subordinadas pelos modos de olhar, pensar e representar. **Objetivos:** Este artigo tem por objetivo analisar aspectos da relação entre geometria e arte que colocam em exercício uma *matriz colonial do poder* na educação matemática. **Design:** Para tanto, apresentam-se algumas cenas, tais como *cena-corpo*, *cena-espaço* e *cena-natureza*, considerando a geometria junto à arte em suas formas históricas e educacionais. **Ambiente e participantes:** Apoia-se na arte, na história da arte e em pesquisas que articulam arte e geometria. **Coleta e análise de dados:** Levantam-se exemplos do uso da geometria na arte analisando, pela *visualidade*, o funcionamento de uma prática que se produz e reproduz a presença e os efeitos da colonialidade do poder, do saber e do ser. **Resultados:** Desvela-se uma realidade ficcional geometrizada e condicionada pelos modos de olhar, pensar e representar, em que a geometria, operada com a arte, conforma-se e coloca em exercício um pensamento colonial, fomentando a desestabilização das relações de poder e saber. **Conclusões:** Por fim, questiona-se: estamos criando em nossas práticas educacionais possibilidades de desterritorializações, de linhas de fuga, de decolonialidade, para nos aventurar com outras atitudes dentro dos dispositivos disciplinares em educação matemática? É preciso, pois, pensar mais sobre as verdades colocadas do que afirmá-las: por um novo *ethos* ético, estético e político em Educação Matemática.

Palavras-chave: Ensino de Geometria; Colonialidade; Decolonialidade; Matemática e Arte.

ENTERING THE FLOW: OPENING SCENES

La géométrie secrète des peintres is the title of a book that claims to testify to the triumph of geometry in the artistic composition of many painters

(Bouleau, 1963). In the introduction, the author exposes his passion for research by questioning artists, based on their works of art, from the point of view of the employment of a geometry they used to carry out their art. Thus, the book brings an analysis of artistic works ranging from the Middle Ages to paintings considered to be from the modern era. The author argues that the secrets of the *formal beauty* of a work are in its genesis. With that, when asking *what the art of composing a picture is*, he aims to pursue the use of geometric figures or any other geometric construction procedure that, over time, made possible the beauty and harmony of the works. The author says:

Painting is not just a flat surface; it undertakes the conquest of space, and the different stages of this conquest, in turn, will be expressed in the composition: conquest through geometry, which uses three dimensions, conquest through light and shadow¹. (Bouleau, 1963, p.11)

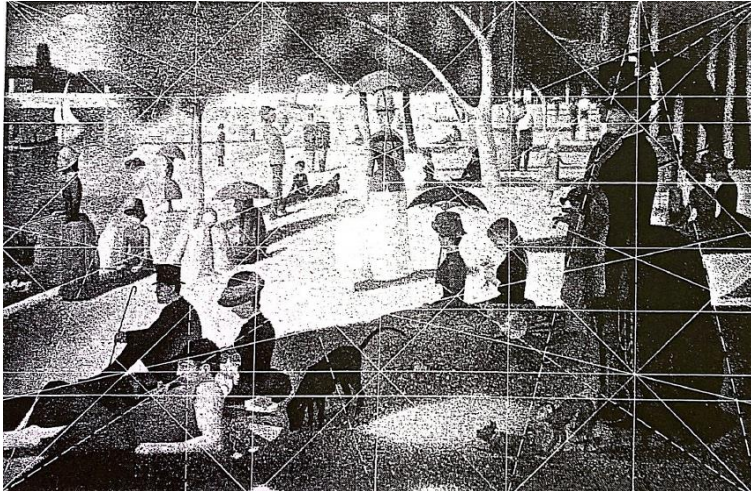
To this end, the author makes diagrams in several works, verifying, analysing, and discussing the geometric techniques used by the artists, which imprints a precise, harmonic aesthetic composition on the work. To a large extent, artists favour employing lines, measures, rules, and geometric figures. The author also says that each era brings a characteristic geometry. From the Middle Ages, the higher use of circles, semicircles, the golden section, and the rule of $\frac{2}{3}$ mixed with new rules and styles from the Renaissance to the contemporaneity.

As an example, we highlight the painting *Un dimanche d'été à la Grande Jatte* (Figure 1, by the neo-impressionist Georges Seurat. Bouleau says that in this work, the artist expresses his taste for exact geometry, choosing the rule of $\frac{2}{3}$ to balance the sides of the painting. We also notice that Seurat overuses semi-cylindrical shapes to give viewers an impressionist perception of the open umbrellas, the silhouette of women, and even animals. A precise, conscious composition can be seen there since, for the artist, *art is harmonic*, with harmony achieved through the use of colours, tones, and contrasts, but also lines, angles, diagonals and horizontal projections.

1 “La peinture n'est pas seulement surface plane; elle entreprend la conquête de l'espace et les différentes étapes de cette conquête s'exprimeront à leur tour dans la composition: conquête par la géométrie, qui recourt aux trois dimension, conquête par la lumière et l'ombre” (Bouleau, 1963, p.11).

Figure 1

Un dimanche après-midi à l'île de la Grande Jatte. Georges-Pierre Seurat. (Bouleau, 1963, p. 211)



Well, we do not intend here to delve into that type of research, per se, making a historical analysis of how the paths of geometry intersect and mix with those of art in an exposition of changes in the practices of representation, although we consider this type of research interesting and fruitful for mathematics education. Instead, we want to touch the point where geometry and art colonised each other and vice versa, leaving us a legacy on how to look at a work of art and the geometric truth contained in each one. The geometry we want to address is the one practised in the western world and that significantly impacts artistic composition and the subjects' relationships with themselves and the world. There we can deal with a *colonial matrix* that creates strategies of power, knowing, and being, subjectivating subjects and collectivities.

Therefore, it is worth highlighting the problem of the relationship between geometry and art in its function of teaching and learning mathematics at school. In this case, not as much as its possibilities and powers, but verifying that this relationship does not hide coloniality, and recognising that it is how colonial practices of power in mathematics education are configured and put into practice. Therefore, it is worth saying that coloniality is understood not only as a pattern of power that emerges due to modern territorial and political

colonialism but in its triple dimension: power, knowing, and being (Mignolo, 2017). Walsh (2008) also adds the colonality of life and nature, i.e., four interconnected axes that promote antagonistic relationships and affirmation of specific cultural, social, political, territorial, racial, gender, and sexual identities and hierarchies. Within this matrix that operates a colonising movement, Valero and Garcia (2014, p. 498), among others, highlight a necessary process linked to the “education of colonised populations, in particular, mathematics teaching and learning”.

Now, when we encounter this historical condition to which we are subjected, and taking this colonial matrix of power as an analytical direction, we set off to think about the relationship between art and mathematics in the classroom, rummaging into what we have been doing in our practice with mathematics and art workshops². Located on the border between *visuality, art, history, mathematics, and education*, our research has usually aimed at problematising and reinventing ways of teaching and learning mathematics through images and artwork. However, one point strikes us: when we *think about what we see* in a work of art, we come across the thesis that a look was colonised, manufactured, and moulded, being the result of a technique (perspective) that, after all, educates the look, guides knowledge, and imposes a way of representing (Flores, 2007). Further, amid the analysis of the workshops, we think that “if mathematics forms, rationalises us, and gives us power and knowledge, it also overwhelms, invades, consumes, and blinds us” (Flores, Kerscher, & Francisco, 2018, p. 140).

What comes first to us is the idea that there is *a* hegemonic mathematics. This Mathematics, with a capital letter, only allows us to see some already ordered things and follow a specific direction; in fact, “Mathematics has become the objective expression of reason” (Bello & Sanhonete, 2018, p. 146). This means, thinking along with Souza and Fonseca (2010), that there is a mathematical thought posed, incited by Cartesian rationality, that is engendered in the production of our subjectivity and interposed in the ways of thinking, speaking, and being in the world, to the point of colonising power, being, and knowing (Ballestrin, 2013), and crossing mathematics teaching and learning. Clareto and Sá, quoting François Châtelet, point out that:

2 They are workshops with experiments involving mathematics and art, developed by the Group of Contemporary Studies and Mathematics Education (GECEM/UFSC). The workshops take place in basic and in higher education, and also in teacher education courses. For more details: <https://gecem.ufsc.br/>.

Cartesian rationality becomes hegemonic and mathematics ‘constitutes itself as a global body, with its rules, its language, offering the image of an integral, transparent rationality’ (Châtelet, 1997, p. 59). [...] This Mathematics is the one that is now incorporated into school curricula, considered as *the true* and *the only one* to deal with the reality in which we live (Clareto & Sá, 2006, p. 6, emphasis added).

Hence, mathematics operates -both inside and outside educational institutions- to provide conditions so that specific things can be said about a given reality through “a productive discourse (accuracy, certainty, perfection, rigour, predictability, universality, indubitability, objectivity, [...], linearity, etc.) that is established as *truth*, and institutes *truths* about mathematics in western society inside and outside school” (Souza & Fonseca, 2010, p. 306, emphasis added). This is because language makes possible some ways of saying and doing while making others invisible, producing truths that delineate and even constitute, what can be seen, said, known, thought, and done (Biesta, 2017).

That said, we set off to face a challenge, undertaking a movement to denaturalise this hegemonic way of knowing, exercising a posture to unlearn to think solely from its references, i.e., in particular, the geometry knowing that art puts into practice. Well, what we want, after all, is to align ourselves with attitudes such as detachment, openness, disobedience, vigilance, and epistemic suspicion, urged by a decolonial posture (Lander, 2005).

To this end, let us return to the workshops in research works with art and mathematics developed by Moraes (2014), Francisco (2017), Wagner (2017), Kerscher (2018), and Souza (2018). Briefly, those workshops must trigger

[...] visualities, knowings, and experiences; show ways of looking, conceiving, and drawing, in which the naturalisation of mathematics in the representation of things in the world, including art, opens itself to criticism and denunciation of hegemonic forms and to the creative form of thought, opening up to multiplicity, heterogeneity, and the invention of new possibilities. (Flores & Kerscher, 2021, p. 30)

Revisiting the workshops³, we realise that mathematics with art implies in thinking almost the sameness of the visual: proportional, geometric, harmonic forms, at the service of a customary, well-balanced representation, within normalcy, in specific Cartesian rationality (but, somehow, also Euclidean or Platonic, since “this way of conceiving mathematics has been constantly updated” (Souza & Fonseca, 2010, p. 306), in a complex way. Thus, it is noteworthy how mathematics and art in practice in the classroom keep flirting with an aesthetic and epistemic order of the western world, with a unique relationship of looking and thinking with art, identifying geometric shapes and concepts and, above all, illuminating ways of looking at the body, nature, society, school. It seems that there is some naturalisation that operates through the reproduction of a type of knowledge that maintains and is maintained by the power relations that are detached from the practices and discourses of Eurocentric rationalities. At this point, we echo a *decolonial option*, i.e., from our stance, we question and denaturalise truths so rooted in our school culture and society.

There is a world of the concrete experience of art lived by the individual and society that is governed by the aestheticisation of life. It is worth remembering that aesthetics emerges in European Modernity as a discipline to formulate universal principles of classification and judgment of beauty and to govern imagination and sensibilities, creating subjectivities. From this, according to Rancière (2009), aesthetics as a form of experience is not just art theory, but a mode of visibility and a regime of interpretation. It is the configuration of what can be seen, felt, and what can be spoken and thought about something.

So, let us imagine the following episode. Tuesday afternoon. It is sunny, but we can see some clouds through the window crack. We are students, and we are in a classroom. Some images are arranged on a blue cardboard set on the table (Figure 2). The images are works of art by different artists. We are all invited to look at them.

3 This revisit is one of the objectives of the Research Project entitled “Formas e de-formas no olhar: por uma educação matemática fronteira e criadora” [Shapes and de-shapes in the eye: for a borderline and creative mathematics education], developed by the first author in the CNPq productivity research modality.

Figure 2

Art pictures on the table. (GECEM image archive - Workshop produced by Wagner (2016))



And then, we are asked questions: Can you see math in the images? When looking at the images, can you immediately see math? Moreover, we are also asked: What do these images make you think? What can we see and hear from the images to see and hear? Do the pictures make you think about math?

A kind of surprise. When startled, we must say what happens, either by identifying something or the thoughts we think. Let us look again at the images, let our eyes roam over the images and think about the questions raised. The possibilities could be multiple, but we suspect we can hardly escape. What stands out is the recognition, identification, and description of some geometric shapes and concepts. Geometry insists on invading our eyes: a rectangle, circles, rounded shapes, a triangle. Our eyes slide a little more over the images:

there are parallel straight lines, curves, the inclination of bodies; it is proportionate, it is disproportionate; it is symmetrical; people have a given volume, there is a depth in the landscape, etc.⁴

Immediately, a question accompanies us. Are we captured to see like this and, why not, also represent geometrically things in the world? Then, other forces and ways in our thinking move us: How and from where does our geometrised look at things in the world emerge? From what we have been investigating: How and where does the idea that working with mathematics and art is to see geometry in art come from? Or, how and from where does the idea of using mathematics (geometry) to produce art come? Still, why do we consider art a possibility to see mathematical, geometric elements? How and where does the idea that working with mathematics and art means seeing in the foreground geometry in art emerge? Does it also mean identifying mathematical elements in the art to the point of being incorporated and repeated in our educational practices? Those anxieties flow and appear without the pretence of bringing assertive answers about and with them. However, it makes one think.

From all this, it occurs to us that:

Mathematics, for example, is linked [...] to power structures; it is also true, if it were not for the way it is taught, how mathematics consensus is organised, it works in a closed circuit, it has its values, determines what is good (true) or evil (false) in mathematics, etc. This does not mean in any way that mathematics is just a power game but that the real mathematics game is somehow linked [...] (Foucault, 2006, p. 282)

Let us re-think the mathematics and art activities developed in the above research. From the analyses and experiments of teaching mathematics through art workshops, we observed that what we have offered is rather a topology of reality about geometry, a transit through possibilities of thought from the new with the novelty through repetition or, perhaps, reinvention of

4 During 2020, during Adamo Cuchedza's thesis work (undergoing), a thinking exercise was also produced with works by Mozambican artists with the members of GECEM. In that exercise, the geometric concepts involved in the look stood out in relation to those works.

what is seen and heard, but not necessarily an analysis from a perspective of *coloniality* of those processes of repetition and reinvention of thought.

Therefore, we set out in an exercise, as a trial, inspired by Foucault, who says:

We must try to analyse ourselves as beings historically determined, to a certain extent, by *Aufklärung*, which implies a series of historical research as precise as possible. (Foucault, 2005, p. 345)

Also:

[...] We must consider the critical ontology of ourselves certainly not as a theory, a doctrine, not even as a permanent body of knowledge that accumulates; we must conceive it as an attitude, an *ethos*, a philosophical path in which the critique of what we are is simultaneously a historical analysis of the limits placed on us and proof of their possible overcoming. (Foucault, 2005, p. 351)

A way and an attitude of being in the world, a philosophical *ethos* of problematisation. A practice that we have been exercising and experimenting with, above all, in mathematics education. A practice

within the scope of criticism, of the denunciation of a state of things perpetuated by modernity, [...] and the invitation to a collective construction of elements that can connect and reconnect, producing new panoramas, new possibilities. Education that is thought, lived, and practised as becoming and opening (Gallo, 2018, p. 804).

Hence, some scenes of art, geometry, and research with mathematics and art in mathematics education gain a specific plot in our analysis to think about with geometry. Therefore, we analyse through visuality the operation of some practices in which the presence and effects of *coloniality of power, knowing, being, and life*. Thus, we present, first, briefly, the scene reverberating in us for some time: the *body-scene*. This scene speaks of a geometry that paints the human body: bodies that are measured, proportioned, symmetrical, related to space by shapes, harmony, order, and the universalisation of an ideal body. Next, in the *space-scene*, the curtains open to make us think about relationships with space, a space given by geometric shapes, measured, in perspective, calculated. And finally, in the *nature-scene*, landscapes are put on stage and

geometric shapes and perspective are exercised, again, in the look, in a constant and unquestionable practice in which coloniality insists on putting itself into practice.

BODY- SCENE

Some time ago, the question of the representation of the human body entered the scene in our research.⁵ This interest arose when we realised that in our activities with mathematics and art workshops in elementary school classrooms, what was mediated was that the visualities that a body is only a body when it has volume and is in a certain naturalised order of representation and visualisation; that it is only beautiful when it is symmetrical and that it only has functionality when it is proportional; therefore, it is a stereotyped body, within specific normality, in specific rationality, at the service of a customary representation (Kerscher & Flores, 2020a). Such discourses take place through the visual and are entangled in our ways of looking and talking about the human body, reverberating in a mathematics that is the effect and agent of specific practices of representation, in which geometry gains a certain visibility and is managed as a technique and support for representation and visualisation.

Mateus: *Make a body as it should be... It must be proportionate, Lucas... Pro-por-tion.*

I: *Why does it have to be proportioned?*

Mateus: *Because proportion makes it beautiful... Imagine.... Look at that big head on a small body... Look at the size of those small legs.* (Moraes, 2014, p. 175).

Therefore, we perceived in this movement that geometry is a rational way of representing the body, characterising it in the ways of speaking and idealising it. In other words, there is a particular search for perfection in which

⁵ For more details on this discussion, see: *Formas matemáticas no olhar sobre o corpo humano: pensamento, técnica, arte e educação* [Mathematical shapes in the look at the human body: thought, technique, art, and education] (Kerscher & Flores, 2020a) and *O caso de uma matemática que fala do corpo que se olha. Ou, o corpo que se olha com a arte e fala de matemática* [The case of a mathematics that speaks of the body that is being looked at. Or, the body that is being looked at with art and talks of mathematics] (Kerscher-Franco & Flores, 2022). Yet, one can look at the relationship of mathematics with art and the human body in the works of Machado and Flores (2013) and Flores (2015).

geometry is managed for the functioning of a given discourse, being also an agent of an aesthetic of modes of representation (Kerscher-Franco & Flores, 2022).

This way of seeing and talking about the body, it seems to us, is steeped in history. Tucherman (1999), in developing a brief history of the body, points to the Pythagorean capture in what is called the *western way of being*, i.e., a subjectivation that produced a difference with the non-western and affirmed a logic of thought for our cultural experience, relating to the use of geometric shapes to represent or symbolise nature and even the human body. Moreover, the human body, according to Sant'Anna (1995), has always been an object of worship and study, of punishment and commercial exploitation. The artistic and scientific images show fears linked to illness, old age, suffering, and death. But is the image just a means of accessing the concept, reality, sense, or meaning? Or, on the contrary, an *event* offered as a sensitive presentation of an order that is only visible in and through it?

In the European Renaissance, the representation of the human body through drawing and painting began to be an object of reflection, as well as all artistic creations. Artists claimed the superiority of painting based on the argument that it presented its own form of knowledge. The study of drawing of the human body, and all artistic painting, thus began to establish itself as a mental activity that was situated as the highest activity of the spirit, claiming it as a science. As an object of scientific study, the body is also scientifically represented. Therefore, mathematical and geometric knowledge linked to the ideal of beauty or the need to break down body parts begins to function as a support for drawing and representation. On the other hand, “the drawing became painting when the colour absorbed the trace, and above all when the colouring covered up the graphic traces” (Kern, 2006, p.19).

From all this, teachings were created and treatises were formulated for the scientific design of the body, following the example of classic painting treatises such as Piero della Francesca, Leonardo da Vinci, and Albrecht Dürer, among others. Classical and contemporary paintings convey images of the human body that are either produced through mathematical knowledge or thought structured by beauty aesthetics.

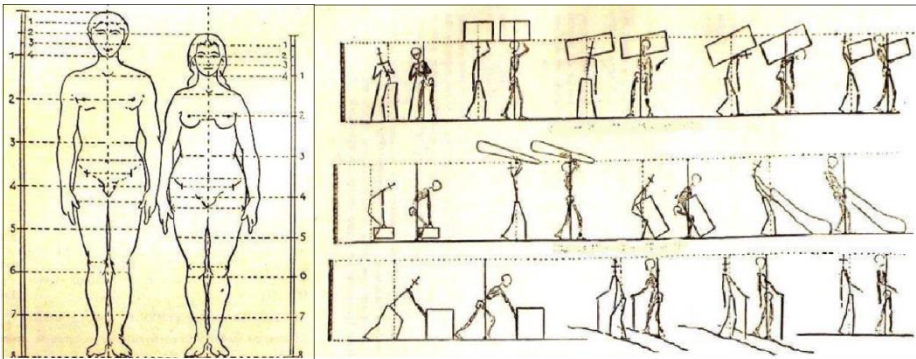
Thus, with the body-scene, traces reverberate for the ways of looking at and representing the human body, both at different moments in the history of its portrait and the current looks for it. In this flow, our analysis also focuses on the techniques, forms, modes, and thoughts employed in paintings, verifying

how geometry organises itself and organises the look and thinking in the present. Let us see the following example.

João Zeferino da Costa (1840-1915), a Brazilian artist and professor, registered in a didactic manual, *Mechanisms and Proportions of the Human Figure* (Costa, 1956), how the proportions of the divisions of the natural configurations of the human body should be represented so that the human figure is in harmony with the whole in the division of its parts. The artist wrote about body drawing techniques, using a classic model to proportion the drawing of the human figure, employing specific mathematical knowledge and teaching them for the artistic representation of the human figure. There are records of his numerical tables of proportions, one of which is in relation to the proportion of an adult woman: eight heads subdivided into four parts, as for the man (Costa, 1956). Other numerical tables and models of the artist's drawing tell of how the figure should be positioned for the ideal movements in different everyday attitudes: when the body is carrying something, supported somewhere, pulling, pushing, climbing; and this understanding that the curvature of the image must be in harmony with the centre of gravity of the figure (Figure 3).

Figure 3

Composition of sketches of the human figure made by João Zeferino da Costa. (Costa, 1956, p. 64 and p. 33)



They are techniques the artist built in his style and that come from his education from other European artists, who modulate the look to see and draw the images in a specific way. Such techniques have been manifested since the

Renaissance (Kerscher & Flores, 2020a), and we see them echoing today in the visualities exercised by the workshops.

They are techniques of drawing, painting, screen space distribution, geometric shapes, and three-dimensional visual impressions. There are conditioned ways of looking, techniques of and for looking; techniques that are in the look. In Crary's words, "these are disciplinary techniques that requested a conception of visual experience as something instrumental, modifiable and abstract, and that would never allow a real world to acquire solidity or permanence" (Crary, 2012, p. 32). And more, techniques that are exercised to control and manage life, a disciplinary model, a technology that modulates subjectivities, a *biopower* as taught by Foucault (1989).

There is, therefore, a geometry that captures us, in other words, a mathematical aesthetic of the gaze that designates and holds us in a model of thought, i.e., that linked to geometry for the representation of a body that is measured and proportional (Kerscher & Flores, 2020a; Kerscher-Franco & Flores, 2022; Machado & Flores, 2013; Flores, 2015).

SPACE-SCENE

From what can be seen and said in the art and mathematics workshops, we highlight an idea of space. We see the enunciation of a space given by geometric shapes, therefore, geometrised, in perspective, organised, intertwine not only with art but also with the school routine and speeches, drawings, and writings of the students who participated in the workshops. It even seemed to us that the act of seeing is already framed and loaded with codes that pervade our culture and permeate our historicity: "our look has no way out; it is colonised to rebuild a rational, perspective world" (Flores, 2007, p. 171).

What are the visual rules linked to the look, thought, and representation of space? In art, how does space become constituted so that we think about it and look at it in a specific way? Does geometric thought in some way operate as a practice in our relationships, reverberating in the scrutiny of the space in which we live, paint, and represent, to the point of looking at the world and seeing it, relating to it in this way? With those questions, therefore, the functioning of the statement about the geometrisation of space and what it allows us to think about mathematics education come to the fore.

Figure 4

Trambolhão: 5ºB, 18.04, III. (Kerscher, 2018, p. 92)



Maria - *Sofia will now choose stones.*

Sofia – *It's just that you have to get the smallest ones to fit in the boxes, right, you can't just put a big stuff here.*

Amanda - *A big stuff!*

...

Angelica – *This one is a bit difficult, isn't it?*

Marta – *Mind you, Maria, Sofia said it right, you can't take a big stuff to put in there.* (Kerscher, 2018, p. 93).

At the workshop *Color Rhythms*, produced by Kerscher (2018), with children in the fifth grade of elementary school, students are challenged with a “big stuff” to put inside a box (Figure 4). Objects occupy specific spaces in the world, and that stone could not occupy the internal space of a rectangular prism whose shapes did not coincide with the spherical and irregular shape of the stone. Saito (2014) says that the space with which we relate is connected with the physical space, the concrete space itself, and the physiological space, a space that has to do with the perceptive space. In this sense, a notion of space that reverberates is one that our experience produces. How are spaces occupied? How do we occupy it? However, there is still another relationship, in our view, that concerns a more abstract notion, a geometric notion of space (Saito, 2014).

Such a scene gave us an opening to think about a specific form of spatial organisation that has been subjectifying us for some time. We, therefore, face the idea that we included in our visual field a type of rational organisation of space, i.e., a geometric space. A space organisation principle constituted by measures, measurement and dimensionality, a geometrised way of spatial structuring.

We now return to a drawing in the workshop *Colours in Shape* (Kerscher, 2018, p. 158), more specifically, we return to what the children perceived in relation to the height of the house and the person drawn:

Mateus - *Look at the size of the guy, look at the size of the house.*

Pedro - *It's just that the house is further away, man.* (Kerscher, 2018, p. 158).

When looking at the elements of the drawing they were making, the children fit them into a logical perception in which the perspective scrutinises the visual plane. It was necessary that the shapes in the drawing were arranged so that it was harmonious and organised in relation to the space that each item occupied so that it approached reality. In this environment, perspective comes into play: the house was further away than the person, it was only necessary to look correctly, and everything would be arranged correctly in the image. This is also what perspective is: “a mathematical method of organising space, fulfilling the requirements of both ‘correctness’ and ‘harmony’” (Ritto, 2012, p. 98, emphasis added).

However, “space in perspective is not an abstraction of physical space, but another space, manifested by the representation of different objects that create a three-dimensional optical illusion assimilated by geometric space” (Saito, 2014, p. 1). Therefore, it is necessary to fictionalise reality so it can be represented somehow (Rancière, 2009). Geometry, through forms, organisation, orders, measures, and dimensionality, as a device, puts to work a discourse of fiction, i.e., of spatial rationalisation of reality: “a representation of space that is presently homogeneous, continuous, and infinite based on geometric concepts” (Flores, 2007, p. 79).

Also, according to Saito (2014, p. 9, emphasis added), “‘what is seen’ and ‘what things are’” do not coincide. In this sense, countless ways are created to represent the space and objects in it.

The representation of the world and things in the world has more to do with the way of looking at, perceiving and conceiving the world than the world represented in itself. That is why the way of representing the forms of the world has history, just as the world has history, i.e., they are cultural constructions, or rather, they are interpretations according to categories specific to the historical subject in question. (Flores, 2007, p. 30)

Those interpretations, constituted over time and culture, are operated and put into practice and, in turn, normalise ways of looking, thinking, and being. A model under development dictates some rules and establishes truths due to a practice of power that operates in that relationship with geometric knowledge, for example, a knowledge that intersects with the representation and perception of space. Such representation and perception, therefore, are related to the movement of the modern/rational subject on its relationship with the world. Therefore, there is a colonisation of the gaze, a colonisation of ways of seeing the world and looking at the world. This is because, as Mignolo (2017, p. 3) denounces, “there is no modernity without coloniality”, and the modern subject, through geometry, in the game of producing ourselves, colonises the ways of looking at and representing space: a space given by geometric shapes, then, geometrised, in perspective, organised. In contrast to the medieval contemplative human being, the modern human being is:

[...] the one who looks, thinks, reflects, plans, and designs space and things in space. Therefore, a rationalising gaze whose “... eye of classical rationalism examines, compares, scrutinises, measures, analyses, separates...” (Bosi, 1990, p. 77). Thus, it is a rational view of space and the three-dimensional objects that are there. It is the search for unity, mastery, and the totality of things (Flores, 2007, p. 82).

From this plot, to the *colonial matrix of power*, pieces are added, giving visibility to a specific rationality that is intertwined with the control of knowledge, subjectivities, and forms of existence, which produces specific ways of looking, thinking, and representing the world, making others invisible or ignoring them.

NATURE-SCENE

“Would geometry be in nature or be a support to understand and explain natural forms?” (Wagner, 2017, p. 110). From work in workshops and with teachers, Wagner (2017) instigates. Hence, another provocation arises: Is mathematics in everything? Is our gaze inclined and trained to see mathematics in things and use its vocabulary to talk about the world and what is in it?

Ma: We already look at it with a look like that, right...

Lu: With a mathematical look, to see if everything is accurate! (Wagner, 2017, p. 122)

Figure 5

A winter day in the Luxembourg Gardens. Marià Pidelaserra - 1900
(Wagner, 2017, p. 77)



Let us approach Marià Pidelaserra’s work (Figure 5). The artist paints a landscape. A garden on a winter day. A nature scene. With the landscape, we are attracted to the form of distribution of the plantation. The trees were planted

one behind and next to the other in a given order. Because of the cold winter, the trees have already lost all their leaves. We see benches scattered throughout the space, all empty, a landscape waiting for something to happen.

Our eyes roam the image once more, this time more attentively. Again, a visual organisation points to a central point. The trees in rows, forming transverse lines, direct us towards the effects of depth in the work. A decreasing scale causes our gaze to be oriented towards things receding in the distance. “The way of organising and arranging objects on the scene, the effect of triangulation and geometrisation of shapes and perspective make emerge, together with the statements, a way of representing, but also of locating oneself in space” (Wagner, 2017, p. 148).

Is it an attempt to imitate reality? It could be so, since “to imitate external reality is not just to copy it nor to reproduce it more or less faithfully. It is a question of counterfeiting nature, and the mathematical method constitutes the means of this counterfeiting, of this *mimesis*” (Jimenez, 1999, p. 44-45, emphasis added). In the Renaissance, for example:

Imitation constitutes the dominant aesthetic principle. Art has Nature, Man, or God as its object. For the Quattrocento, mathematics, geometry, and arithmetic constituted the means of applying this principle. (Jimenez, 1999, p. 44)

In this sense, geometry comes into play to organise the practised aesthetics. Regularities are at stake, since mathematics “constitutes itself as the ‘science of regularities’” (Clareto & Sá, 2006, p. 10). In the Renaissance, the idea of looking at the image and producing it as a window cracked open to the world, in perspective and without estrangement, idealising the symmetry and organisation of things (Flores, 2007). This look, we think, is a colonised and also colonising way, that is, effect and agent, dictated by modern western culture, based on the geometric, perspective, rational idea of the world, managed by our historicity and repeated, exercised by and in the practices. This is because the West supports a specific type of thought linked to reason, causality, and non-contradictory.

There are, therefore, forces and knowledge that relate and are made as truths among history and practices, whether social, cultural, or educational, producing effects at the same time as they are produced, creating a naturalisation of our ways of looking at things in the world and managing, in some way, a form of organisation, ordering, structuring, and dimensionality,

that is, a geometrisation of the world. In short, a coloniality of powers and knowledge associated with a coloniality of being and life.

ON SCENE: GEOMETRY IN THOUGHT

Because, my students, strange as it may seem to you, you are being shaped by the subjects we teach you. (Pennac, 2008)

We see on stage, therefore, a geometrised fictional reality. In our history and culture, in our practices, there is, therefore, an agency of geometry for the constitution of ways of looking at and thinking about the world. Fictional, because:

What is a point if not something without dimension? What is a line if not something that has no width? What is a plane if not something that has no thickness? Elements that describe the real, however, not reality themselves. They are abstractions, idealisations, and imaginations that are nothing like what we experience or find in our world. They are the first intuitions designating objects and things by utility, preventing us from knowing them except through abstraction. (Kerscher & Flores, 2020b, p. 9)

Thus, from this fictional reality, discourses about (dis)proportionality, (as)symmetry, squaring, framing, shapes, order, harmonisation, organisation, dimensionality, etc., about the world are also on the scene. So, those relationships are in the ways we express and represent ourselves, talk about things, the world and ourselves, which we understand as an aesthetic of thought (Kerscher-Franco & Flores, 2022) and which sets in motion, and exercises, the colonial matrix of power in mathematics education.

We understand that geometry is not only a set of theorems, concepts, and forms to be apprehended. It is also a *device* (Foucault, 2010) that, imprinted in our thinking, makes us talk about the world and the things that are in it, i.e., it participates in the game of relations of power, knowledge, being, nature, and life, producing truths that are reiterated and subordinated by the ways of looking and representing, subjectifying us. Nevertheless, despite the power relations involved in this movement capturing us, they also produce positive effects in terms of knowledge, since “power, far from preventing knowledge, produces it” (Foucault, 2010, p. 148). In this game, in terms of strategies, the

geometric discourse produces knowledge about reality and our world. As suggested by Pennac (2008) in the epigraph of this section: *you are being shaped by the subjects we teach you.*

However, thinking about the relations of knowledge and power implies revealing a colonialist use of mathematics in art and a colonising discourse in mathematics education. Geometry is in our ways of looking at and relating to the world, capturing us, dictating rules about what to describe and interpret, or even insinuating how to address everything and everyone in life, society, and nature. In turn, mathematics education, embracing and promoting that idea, reiterates and puts into practice the colonial matrix of power.

We then say that our thoughts are colonised to see things in the world this way, geometrically. Moreover, that mathematics education also colonises the ways of operating with art and mathematics in teaching. Further, it contributes to the exercise of coloniality, promoting social, cultural, political, territorial, racial, gender, and sexual differences. This colonisation can be understood as a territorialisation, i.e., “territory is the domain of the having” (Deleuze & Parnet, 1996, p. 3), a blocking of flows in which established truths are always affirmed, reiterated, and reproduced.

Perceive the scenes as triggers of thinking. They are not here to corroborate or prove a possible veracity of the thoughts raised about the plot of a colonial matrix of power of mathematics in art. On the contrary, the scenes are there to make us think: how are these practices of knowledge instituted, formed, and promoted in power relations and historical and cultural practices? There are, it should be noted, other ways of perceiving art and its relationship with mathematics. However, the one that strikes us at this moment of thought is the one that relates geometry to looking at art, making it, interpreting it, and representing reality, reverberating in a colonising and coloniser way in mathematics education.

Let us also think: are we creating, in our practices, possibilities of deterritorialisations, lines of flight, and decoloniality to venture out with other attitudes within the devices in mathematics education? This is because “leaving the territory is venturing out” (Deleuze & Parnet, 1996, p. 3), an opening to multiplicity, to flows, to the invention of other possibilities, to inciting thought and destabilising regimes.

There are ways to look at things, to know, to represent things in a society that are so imperative that we think that everything happens in the most natural, neutral way. So, not to question

them is to allow authoritarian influence, it is to give up the understanding of the historicity of our way of looking, of representing, of knowing and, ignorantly, letting ourselves be manipulated. (Flores, 2007, p. 176)

Therefore, we must “shake up habits, ways of doing and thinking, dissipate accepted familiarities” (Foucault, 2006, p. 249), blur boundaries, mobilise boundary mathematics and geometries, and create a new *ethos* in thought. An *ethos* of questioning the truths in an ethical, aesthetic, and political movement in mathematics education in an option that subverts, and, in a profane act, suspends the colonial matrix of power.

Finally, we operate from the denunciation perspective that is placed as a cultural critique of the historical configurations of the imaginary of the colonial/modern system, based on the coloniality of power and on the colonial difference that historically produced a kind of geopolitics of knowledge that subordinates not only knowledge, peoples, and cultures, but also other ways of thinking, seeing, and representing. All of this means, therefore, denouncing hegemonic practices both in dealing with mathematics and art and proposing and expanding the ways of seeing and speaking of mathematics, with mathematics, about mathematics, teaching and learning mathematics with images of the arts. Through a philosophical attitude of a critical ontology of ourselves, an analysis of ourselves as historically constituted beings, as Foucault teaches us, takes us to a perspective of the border, a liminal thought, once again asking: “How can a mathematical education (be) transforming?” (Kerscher & Flores, 2019, p. 3).

AUTHORSHIP CONTRIBUTION STATEMENT

CRF conceived the idea of this article, developed theoretical and practical arguments for its characterisation and defence, and adapted the analysis methodology to the written text. MMKF raised, treated, and discussed examples and collected data for the discussion. Both authors actively participated in the discussion of the results and reviewed and approved the final version of the work.

DATA AVAILABILITY STATEMENT

The data supporting the results of this study are openly available at: <https://repositorio.ufsc.br>. This data was derived from the following resources available in the public domain:

<https://repositorio.ufsc.br/xmlui/handle/123456789/130964>;

<https://repositorio.ufsc.br/handle/123456789/191266>;

<https://repositorio.ufsc.br/handle/123456789/203117>;

<https://repositorio.ufsc.br/handle/123456789/203035>;

<https://repositorio.ufsc.br/handle/123456789/203137>.

ACKNOWLEDGEMENTS

We thank CNPq for granting a productivity scholarship to the first author and CAPES for granting a doctoral scholarship to the second author.

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