Shaping a Scientific Self: A Circulating Truth within Social Discourse

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In this paper we illustrate how a truth circulates within social discourse. We examine a particular truth reproduced within science, that is: through the understanding of Euclid's axioms and postulates a person will gain the access to all human knowledge. We deploy a discourse analysis that helps us to understand how a truth is reproduced and circulated among diverse fields of human knowledge. Also we show why we accept and reproduce a particular discourse. Finally, we state Euclidean geometry as a truth that circulates in scientific discourse. We unfold the importance of having students follow the path of what schools perceive a real scientist is, not to become a scientist, but rather to become a logical thinker, a problem-solver, and a productive citizen who uses reason.

Introduction

We want to tell a story about a circulating truth that has been shaping a scientific self since before science was called science. Even though there are many truths within scientific knowledge, this particular truth seems to resist every attack, seems to win every fight. Within social discourse, it is believed that mathematics is a powerful knowledge that will enlighten people.

> All adults, not just those with technical or scientific careers, now require adequate mathematics proficiency for personal fulfilment, employment and full participation in society. [… Students should] be able to apply them to solve problems that they encounter in their daily lives (Organization for Economic Co-operation and Development, 2014, p. 32).

Then, in order to be the productive citizens that society requires, it becomes important that students develop mathematical thinking.

Students should be able to

> reason mathematically and use mathematical concepts, procedures, facts and tools to describe, explain and predict phenomena. It assists individuals in recognising the role that mathematics plays in the world and to make the well-founded judgements and decisions needed by constructive, engaged and reflective citizens (Organization for Economic Co-operation and Development, 2014, p. 28).

Therefore, mathematics becomes the tool to solve problems from everyday life. In fact, one of the areas that PISA measures is *Mathematising*, this is the ability to move between the, so called, 'real world' and the mathematical world. Thus, schools address the development of this particular ability by connecting everyday life to mathematics. But this link does not always work, because the 'real world' of school is not the physical world. The models that we have to link both are outdated (Burgin, 1987).

School has been developing a 'school space', where everything has a coordinate in a two or three-dimensional Cartesian system. This 'school space' is rooted in Euclidean geometry. In other words, it is shaped by Euclid's axioms and postulates. At school, straight lines are always straight, they do not curve at the horizon, parallel lines are in fact parallel and the sum of the interior angles of a triangle is 180 degrees. However, 'school space' is a space that has been modelled by mathematics which is different from the world the students live in, precisely because geometry provides the materials for models of the physical world, models that are abstract analogies and not the world itself (Ray, 1991).

In this paper, we examine a particular truth reproduced within scientific thinking. The belief is that through the understanding of Euclid's axioms and postulates a person will gain the access to knowledge, not just the access to geometrical or to mathematical knowledge, but to all human knowledge. We are going to deploy a discourse analysis that will help us to understand how a truth is reproduced and circulated among diverse fields of human knowledge. Also it will show why we reproduce a particular discourse through our own language.

How are Discourses Reproduced?

Discourses are not impositions; we are not forced to believe in them. But sometimes, something sounds very reasonable to us, so self-evident, so logical, so common sense that we agree with it and we start to reproduce it through our own language. Who will go against the idea that we need mathematics in our daily life? But we perceive these 'truths' as common sense just because we are inserted in a particular time and place, spatio-temporal conditions, with a particular rationality. We are *subjected* to those self-evident truths.

Foucault claims that "taken-as-truth" statements circulate within social discourses, discourses that are produced because we reproduce them through language (Foucault, 1982). At the same time, these discourses are not isolated; they are produced by the interaction of different spheres of social life and are shaped by statements and their related truths (Foucault, 1972). In other words, discourses do not materialize from thin air, nor are they commandments by a superior force, such as a God or government.

Therefore, truths become a discursive formation, and there exists diverse rules for what is considered to be true and false (Jørgensen & Phillips, 2002). In other words, there are regimes of knowledge determining what is accepted as meaningful and true and what is not. As Deleuze stressed, only statements may be repeated, but these statements "are not visible not hidden" (Deleuze, 1988, p. 10).

For instance, a circulating truth could be that 'school provides tools to achieve success in life'. Some people might agree with this truth and reproduce it, and some people might be against it. In fact, educational sciences have been providing these tools, with the promise of a better future, for the fabrication of a 'cosmopolitan child' (Popkewitz, 2008). If we analyse school mathematics, it was believed that by a 'mathematics for all' it was possible to create this brighter future (Valero, 2013), and that belief has not changed though time. But, why do we say that it is a 'circulating truth'? Recall the PISA quotation above: *All adults require adequate mathematics proficiency for personal fulfilment, employment and full participation in society.* This implies that to be 'productive' and 'successful' one must know mathematics and science.

There are many naturalised truths circulating in the discourse of diverse scientific fields, and such truths constitute unproblematized understandings of its practices. One of these truths is to believe, for example, that Euclid's axioms and postulates became a universal key to access human knowledge (Sbacchi, 2001). In the same fashion, that Euclidean geometry began to appear as a dominant perspective within scientific knowledge (Majsova, 2014). Or, that Euclid's *Elements* are so necessary to every science that we must believe in them as its basis, principle and fundamental elements (Guarini, 1968). So, a particular truth within scientific knowledge has been reproduced.

Building from this truth, what makes Euclid's *Elements* so important? Are the Elements important because it was the only 'recognized' form of geometry until the 19th century? Harrison (1919) stresses that for a great period of time Geometry and the *Elements* of Euclid were considered as synonymous. But, is it the only reason?

> In the 1630s, Descartes's Discourse set out philosophical reasons for seeing Euclid's Geometry as an intellectual model for theories in other areas of inquiry. Fifty years later, Newton showed that this model was not just formally rigorous, but empirically powerful: i.e., it resolved problems that had plagued European thinkers ever since the publication of Nicolaus Copernicus's de Revolutionibus (1543) (Toulmin, 1998, p. 330).

Apparently Euclid's *Elements* were more than just books summarising the geometrical knowledge of his time, Descartes and Newton recognized them as an intellectual, rigorous and powerful *model*. So, the question left is: how has Euclidean geometry been operating in the development of scientific knowledge?

How Can Truths on Scientific Discourse be Analyzed?

Now, we have a truth: "Euclid's *Elements* are a key to access human knowledge". But, how are we going to deploy a discourse analysis to understand how has Euclidean geometry been operating through scientific discourse?

As we stated above, discourses are not isolated, they are produced by the interaction of different spheres of social life. This means that diverse spheres will evolve around certain truths, a certain statement will be shaped. But, at the same time, the same statement might be repeated in other spheres. Bang (2014) adds a new insight to this 'equation', he presents a new framework employing an image of 'quasi-self-similar fractals' to trace entanglements between multiple semi-autonomous fields.

> A new image of thought employing quasi-self-similar fractal—an image better suited to clarifying the issues and understanding the transversals and influences among multiple fields. This new image of thought is an attempt to represent the strange universality or 'universal mechanisms of fields' one encounters (Bang, 2014, p. 54).

To understand how a truth is circulating among social discourses, which means, to understand how 'Euclid's *Elements* are a key to access human knowledge' is navigating within different spheres of scientific discourse, we have to think outside the box of causality (e.g. Daston & Galison, 2007; Popkewitz, 2008). We have to trace the entanglements across scientific fields --- a 'quasi-self-similar fractals' image. This truth moves between the different spheres and also between spatio-temporal conditions. For example, Valero (2013) examines a "taken-as-truth" statement on mathematics education research, this statement is: a "mathematics education for all" is needed. She uses a discourse analysis strategy, which implies a rhizomatic analytical move (Deleuze & Guattari, 1987).

> My analytical strategy involves visiting a number of interconnected spaces that without any linear or strict logical connection […] map different aspects of the statement under examination. […] I also move in the connection of ideas in time and space. As mathematics education research is thought as an international field of inquiry, and probably because for many of its practitioners mathematics is still conceived as a universal activity, […] In keeping my eye on the ideas that circulate across nations I try to make evident how a field of inquiry generates truths that seems to be transferable from place to place and from time to time, contributing in this way to the reification of mathematical ability as a human ability and right that equates with reason, and

> with that installs one unified logic of being (Valero, 2013, p. 6)

Therefore, to analyse how the *Euclidean truth* is operating, we are going to move outside the field of mathematics, then, we are going to be able to see the entanglements across fields, the rhizome.

Is there a Euclidean Truth?

It is possible that one might think that we are forcing the Euclidean truth to appear. As if we were searching for a suspect, then everyone would be guilty. As we previously mention, discourses are produced within different spheres of social interactions. So, how will you react if we state that Euclidean geometry was not only the root for the development of mathematical knowledge? Well, the answer could be simple: physics. But no! Euclid's *Elements* have been entangled across diverse fields, such as architecture, literature, religion, philosophy, political science, and so much more. A 'quasi-self-similar fractal', a rhizomatic web where everything is connected by, the one and only, Euclidean thinking.

By deploying an analysis on the discourse of scientific research fields, about their 'roots', the existence of some beliefs about Euclidean geometry emerged. A truth that states Euclid's *Elements* as a method, the *Euclidean model*, that it was considered the "standard pattern for any "hard" science" (Toulmin, 1998, p. 336).

> Euclid's geometry, for instance, is notable for its rigor in demonstration […] is distinguished for its orderly "progression from the simple to the compound, from lines to angles, from angles to surfaces, and so forth," a method that particularly "contributes to the enlargement of mind and makes us think with precision" […He] develops the propositions of geometry in response to a natural need to know or to a spontaneous order of inquiry […] Any of these three systems increases the student's capacity for reasoning, for understanding ideas, which properly understood are "notions determined by relations" […] It is "nothing more than the faculty of arranging, *facultas ordinatrix*" […] The desire for order leads to the ideas of truth, goodness and beauty (Frank, 2007, p. 251)

From this, it is clear that Euclidean geometry is understood as a rigorous model of demonstration, as a model for 'organizing' knowledge as a progression and, finally, as a response to a natural need to know. These three aspects of Euclidean geometry will increase the capacity of students for reasoning and so forth. It is possible to think that this sort of statement derives from school mathematics discourse, or that it was a result from mathematics education research. But no, it was stated within the field of theology, in 1765, where it was argued how a man, through reason, becomes a man (Griffiths & Griffiths, 1765).

> Euclid's reasoning described a method which [...] provided the foundation for all true reasoning, an abstract scientific method, through which the world becomes intelligible by a means of reasoning which is entirely independent of sense perception (Vinnicombe, 2005, pp. 670-671). Geometry is central to the great philosopher's thought in two quite distinct ways: as methodological guide and example, and as the most basic of all branches of knowledge, from which "synthesis" might deduce, step by step, the immutable laws of social justice (Grant, 1990, p. 151).

In the 17th century, it was believed that a new political science could be established that relied upon the principles of Euclidean geometry, an abstract scientific method, which developed the model for organizing human behaviour. Hobbes, who was proposing this connection, believed that 'geometry was central', a knowledge cannot subsist without a proper method and the key to achieve that method was held by Euclid's reasoning (Grant, 1990).

And those statements about the Euclidean truth have been entangled in other fields,

> In Architettura Civilequite often the elements of geometry become the elements of architecture *tout court*. For Guarini, for example, a wall is a 'surface' and a dome a 'semisphere.' [...] the problem, for him, was not 'how to build' but 'how to draw.' Therefore, not only Euclidean geometry has become a part of architectural theory but it has also carried with it its implied linearis essential (Sbacchi, 2001, pp. 30-31).

It is clear that this quotation above is from architecture. These notions of Euclid's *Elements* were formally introduced in the 15th century by the *Trattato di Architettura Civile e Militare*. Euclidean geometry began to appear as "a good alternative to more complicated numerological calculations […And was probably] the preeminent one among the masses and the workers" (Sbacchi, 2001, p. 27).

It is possible to think that these quotations are old and that they recognize Euclidean geometry as the *model* for science simply because non-Euclidean geometries were not "formalized" until the 19th century. But, in the 21th century, literary education is being rooted in Euclidean geometry, not in the axioms and postulates, but in the model of order, of organizing knowledge, from the self-evident to the most complicated abstractions. Where the self-evident technical literary terminology are assumptions as the role of an "unreliable narrator" in a book or a play, there is no need to define it (Rabinowitz & Bancroft, 2014).

> We are proposing Euclid as a model because we believe that literary education should begin with the fewest possible number of initial assumptions, and that more complicated interpretations, in later years, should come from increased development and subtler manipulation of those assumptions, rather than from introducing entirely new concepts (Rabinowitz & Bancroft, 2014, p. 4)

I Completely Agree with It! Do You?

So, how has this *Euclidean truth* been accepted in the development of scientific knowledge? To reproduce a truth is not to repeat it incessantly, rather to reproduce implies acceptance and agreement. No scientist was forced to think *Euclideanly*, they accepted the *Euclidean model* because it seemed reasonable for them. In other words, they are *subjected* to the self-evident truth of Euclidean geometry's consistency, simplicity, rigour, "progression order" and so on.

This is the second time that the word *subjected* appears. According to Foucault (1982), there is not a domination of the self; no one is forced to do or believe anything by imposition. That is how he understood power. So, this power implies 'the other' as a person who acts on his/her own. Hence, this power depends on the freedom of the subject. Here is when the term *subjected* comes to play; to be subjected could mean "to be shaped in a particular way" or "to be shaped to become a particular self". And every spatio-temporal condition has a 'rationality', a way of thinking and behaving, as codes that are transmitted to people. The game of "being part of" requires the acceptance of that spatio-temporal discourses, not a simple repetition; one has to believe in it.

So, let's return to Euclidean geometry. How has this *Euclidean truth* been accepted in the development of scientific knowledge?

> Since seventeenth- and eighteenth-century natural philosophers took their Platonist ambitions from Galileo and Descartes [...]. From the start, formal systems modelled on Euclid had a charm that carried people's imagination over into fresh fields: if the world of nature exemplified in Newton's dynamics had a timeless order, this could presumably be extended to the world of humanity as well (Toulmin, 1998, p. 353).

> The mathematical method of deduction from axioms had a decisive effect on the social sciences of the Enlightenment. [...]. Find the axioms of human nature, deduce from them in the approved Newtonian manner, and a complete science of man became a possibility (McClelland, 2005, p. 290).

> One of the issues which played a major rôle in most of the discussions of the Theory of Relativity was the simplicity of Euclidean geometry. Nobody ever doubted that Euclidean geometry as such was simpler than any non-Euclidean geometry with given constant curvature [...] Euclidean geometry is the only metric geometry with a definite curvature in which similarity transformations are possible (Popper, 2005, pp. 129-130).

Here the acceptance is not in order to accept the brilliance of Euclid, or to agree to only use Euclidean geometry. Neither is a matter of stating that a science will become science depending on how much Euclidean geometry was used in the development of their field of knowledge. It is an acceptance of Euclidean Geometry as an axiomatic, scientific *model* (Hartshorne, 2000), an acceptance that through a

Euclidean way of thinking people will become a scientific self.

We are aware that not everybody blindly accepted Euclidean geometry. For example Einstein demonstrated that this geometry was only thought to be applied in a void, not in the *real world,* where space is inseparable from matter (Woods & Grant, 2007); "where mass tells space-time how to curve, and space-time tell mass how to move" (Wheeler, in Sweeney, 2014, p. 826). Einstein was referring to Euclidean geometry as a mathematical model of space; however, he was interested in a geometry that provided him tools to understand the physical space. For instance, "it was much later, with Einstein's general relativity, that it was shown that the geometry of the universe is not Euclidean but curved" (Hirsch, 1996, p. 62). We want to be clear that the discussion is deeper than that. We are not against Euclidean geometry. We are drawing awareness to Euclidean geometry as a truth that circulates in scientific discourse and performs, as an effect of power, a scientific self.

So, am I a Scientist Already?

> What Euclid did that established him as one of the greatest names in mathematics history was to write the Elements. [...] Euclid' great genius was not so much in creating a new mathematics as in presenting the old mathematics in a thoroughly clear, organized, and logical fashion" (Brodkey, 1996, p. 386)

Indeed Euclid was a great geometer, probably the most recognized of all time. The *Elements* deploy a schematic *order* from the basic definitions to the most abstract *formalizations* (axiomatics). But this sacredness was not eternal. Not only mathematicians, but also researchers of others fields of knowledge tried to show that Euclidean axioms are in opposition with our optical perception of space. These studies concluded that visual space is far from being Euclidean (Suppes, 1977). But it is possible to find that almost all Western school geometry is based on Euclid's work (Burgin, 1987; Ray, 1991). So, how can we explain this Euclidean resistance? As stated in the previous section, Euclidean Geometry is not just formulas and axioms that need to be applied to solve problems. This geometry is being operated in a completely different fashion.

Does this mean that I will become a scientific self if I accept Euclidean geometry as the 'basis' of all knowledge? It is not as simple as that. Subjectivity does not imply only the repetition of a truth; the acceptance of this discourse will operate in an interesting way. For {Daston, 2007 #33@@author-year;Foucault, 1982 #92}Foucault (1982), human beings become subjects through the objectifying effects of scientific knowledge. At the same time, the practice of knowing generates effects in the form of knowing and in the subjects who know (Daston & Galison, 2007). Therefore, subjects must train themselves to become part of a practice; in other words, they have to conduct their own conduct. Such *subjectification* pursues to fabricate a scientific thinking.

How is this Euclidean truth prompting to a scientific self? The method deployed by Euclid is shaping a deductive and axiomatic way of thinking, a method that "contributes to the enlargement of mind and makes us think with precision [and increases the] capacity for reasoning and for understanding ideas " (Frank, 2007, p. 251).

In the End…

Let's return to school, school geometry is rooted in Euclidean geometry, but this was not intentionally. It was not because someone wanted it there. This geometry is an important part of school due to the circulating truth within 'scientific discourse'. Currently, to become a scientist means to become a productive citizen. Therefore, if we want to have a brighter future we have to be *subjected*, in Foucaultian terms, by schooling.

> Educational sciences have provided the tools for fabricating the cosmopolitan child through being a cornerstone of the planning of social life for the promise of a better and brighter future. […] I connect the statement of the need of a mathematics education for all for creating a brighter future with the way in which educational sciences in the 20th century have produced the elements for the reasoning making possible such statements (Valero, 2013).

Euclidean geometry is much more than a particular way of seeing space or a formalization of the metrics of the earth; it is much more than just learning a set of mathematical concepts and rules. Euclid's elements are deploying a deductive system, rooted in proofs and demonstrations. Euclidean geometry becomes the template or the path to become a scientific self. So, in order to become this scientific self, students must follow the path of what schools perceive a real scientist is, not to become a scientist, but to become a logical thinker, a problem solver, who uses reason! The desired cosmopolitan child (Popkewitz, 2008), as described by the Chilean Ministry of Education when stating:

> School mathematics curriculum aims to provide students with the basic knowledge of the field of mathematic, and, at the same time, helps students to develop logical thinking, deductive skills, accuracy, abilities to formulate and solve problems and abilities to model situations […] The learning of mathematics enriches the understanding of the reality, facilitates the selection of strategies to solve problems and contributes to an autonomous and individual way of thinking (Ministry of Education of Chile, 2010, p. 3, our translation).

This discussion is not about how Euclid's axioms and postulates are the easiest for children, cognitively speaking. The discussion is that Euclid's Elements are a consistent, deductive and progressive system that shapes the way of thinking of a scientist. School geometry also operates by constructing its subjects; it shapes in students a way of visualizing the world and a way of thinking about space and reality. If the method deployed by the *Elements* was the basis of almost all scientific knowledge, then it does not seem such a bad idea to teach Euclidean geometry at schools, right?

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