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Literature, Mathematics, Science, and Life: an example of possible dialogue

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Abstract: In this paper we reflect upon the history of scientific method and its effectiveness as a problem solving strategy in personal and existential matters. These considerations are naturally connected to the history of scientific disciplines as well as philosophy and, over a broader field, to the history of ideas. Moreover, they find broad application both in literature and psychology. The reading of a novel will be the starting point of our discussion on scientific and philosophical related issues, as this allows us to point out the numerous ways in which literature contributed to eminently scientific topics. Hence, the traditional divide between humanities and science appears to be obsolete.

1. Introduction

Among the many issues connected to the history and didactics of mathematics in high school and university education some of them concern links between mathematics, physics, chemistry, biology…

Our main focus will be on the relationship between the methods employed in mathematics and those employed in other sciences, pointing our attention to certain historical aspects during our time in class as teachers of mathematics and/or scientific and philosophical disciplines.

In this context, a key issue of our discussion is what role – both educational and existential – the knowledge related to mathematical method and to other scientific disciplines can play.

This is, indeed, a topic of general interest that concerns both people with a scientific and with a liberal arts education, even though only at a high school level. It is even more important for teachers of every discipline, in particular for those who teach or are specialized in mathematics, philosophy and anthropology, since it is connected to the history of education and to the history of ideas and their transmission in Western culture.

More specifically, dealing with the meaning of mathematical elaboration and its teaching/learning or transmission in high school and university classes, this issue can contribute to overcoming the isolation that mathematics faces and can help finding a multidisciplinary approach that would highlight common features.

The answer to this issue should lead towards the outlining of a general cultural and educational framework, within which all the disciplines should be placed. What can be done in order to make their teaching easier within high school and university educational programs? Given our background (we deal with the diffusion of mathematical contents) we believe that in the teaching of scientific disciplines, preference should be given to

those historical educational paths that contributed substantially to the creation of our present cultural frame of reference.

This requires a certain knowledge of social and political history, history of mathematics, philosophy, medicine, theology, law, physics, biology, psychology,… with the final aim of bringing these disciplines together in a single organic context.

In the present work we propose a modest attempt at a synthesis taking into consideration two different moments.

The first moment can be identified with the creation, and presentation of a text on the history of the mathematical method and its relationship with other scientific disciplines, written by experts in the field of mathematics and its diffusion. The text was, then, presented to high school and freshmen college students, since its main goal is neither to contribute tout court to the history of scientific method nor to give an exhaustive account of the many problems involved, but to raise students' awareness around this topic.

The second moment consisted in the presentation of the text to an audience made up of teachers and junior and senior high school students (scientific or humanities focused high school) who were made aware of our educational path and our role as mathematics teachers.

From the attention and response we received from our audience, our experiment could be deemed to be satisfactory[1] . This induced a further reflection on our choices in preparation for the meeting with the students, and we realized that involving more students in our two moments project could be a useful experience for everyone.

The article proposed is, then, the result and final elaboration of this experience together with a brief explanation of the taken choices.

After identifying the historical progression that moves from the mathematical method towards methods employed in other disciplines, and mentioning its interactions with the economical and industrial history of some Western countries, we looked for ways to keep our discourse more immediate and understandable, since its intrinsic multidisciplinary approach could make it though and irksome.

In order to do so, we chose as the starting point of our work the novel Miss Smilla's Feeling for Snow[2] by Danish author Peter Hoeg (1957). The novel, written in 1992, is a thriller and has a movie3 adaptation as well.

The novel offers many different interpretations and can be read according to multiple perspectives, for example paying attention to how it is written, to its characters (more than one deserves attention), to its diverse contents (philological, historical, scientific, .).

[1] The experiment was conducted during a lesson held at the Avellino's Math high school. This school organized a Series of seminaries on the relationship between mathematics, philosophy, and literature. The lesson was held on May 8 2015.

[2] This novel was published in Denmark in 1992. The author Peter Hoeg is an established Danish writer. His novels, popular in all the world are The History of Danish Dreams of 1988, Tales of the Night of 1990, Smilla's Sense of Snow in 1992 and finalist for the Edgar Award of 1994, Borderliners 1993, The Woman and The Ape 1996, The Quiet Girl of 2006, The Elephant Keepers' Children of 2010 and The Effect of Susan of 2014 . From these novels reveals his solid classical formation (humanistic and scientific).

[3] The director is Bille August, while the main actors are Julia Ormond (Smilla in the role), Gabriel Byrne and Vanessa Redgrave.

Given our background, we chose to highlight a particular aspect, that is, the development of the main character, Smilla. After a further analysis, we identified her as a troubled rebel in search of herself and trying to cope with her deep loneliness. Furthermore, as the narration moves forward, we were able to identify all the hints left here and there in background that can explain her commitment to solve the central dilemma around which the whole plot revolves: the reason of young Esajas' death.

The movie adaptation, for its inherent nature, is not able to give a proper answer to this question because it gives primary attention to the plot, leaving aside the psychological aspects of the characters.

In conveying Smilla's development as a character, we chose to privilege a direct and immediate relationship between the text as it is and the audience, limiting as much as possible every external intervention.

What is, then, the connection between this choice and the exposition of our thoughts on the relationship between the methods employed in mathematics and those employed in other sciences? We are convinced that the novel can be useful to introduce our cultural disquisition. Indeed, presenting a character that shows how an "analytical" mind can contribute to solve concrete problems at different levels of difficulty, poses a pivotal question: can our scientific education contribute to identify a customized "method" to deal with everyday life problems, and if so, by what means? Obviously, the novel is food for thought about many different issues and topics.

After presenting the plot and the extracts highlighting the chosen topic, we could have easily pointed our attention to the role of Euclid's Elements in educational paths or to a discussion on the nature of geometry or to Newton's interpretation of natural phenomena or to the meaning of progress and scientific progress or …

Let us begin with the two parts of our experiment.

2. An organic reading of Miss Smilla's Feeling for Snow

Synopsis. A child named Esajas runs on a snowy roof, falls down and dies. According to the police it is undoubtedly an accident. Smilla Jaspersen, the daughter of an illustrious Danish doctor and a native Greenlander mother, has a great understanding of snow and ice due to her Greenlander upbringing. Thanks to her knowledge and the examination of the footprints and traces left on the roof, she figures out that the child's death is not a mere accident, but the result of a murder.

She starts investigating and comes across shady people and dangerous situations, eventually going back to Greenland on board of a rented icebreaker that is setting sail for an expedition to an empty spot of the polar ice cap. There she finds out the truth, amidst her familiar, feared, and revered ice. Near a meteorite, that her travel companions want to take away, there is a small lake where a cylindrical worm grows and proliferates, the Dracunculus borealis, a parasite with a subcutaneous life.

This parasite mildly affects whales, seals and dolphins, but if harbored by humans, it penetrates their vital organs, in particular the heart, causing death in a short period of time. There were other expeditions before this

(1966, 1991). Esajas and his father took part in the 1991 one. Since the father died shortly after, someone believed that the child could harbor the parasite as well. Moreover, the child was the living proof of what exists around the meteorite. For these reasons eliminating him was essential, since he was the inconvenient witness of a disturbing reality: the spread of the parasite among humans could destroy the whole humankind.

Who is Smilla? Why does she bear this name? Let us, then, introduce Smilla, the main character, her education and studies and her vision of life.

Smilla Jaspersen is a 37 years old woman, born and raised in Greenland. After her mother's death, she moves to Denmark to join her father who puts her in a boarding school to make sure she has a proper education (she changes many of them because of her difficult character). During her university years she specializes in the study of arctic regions (she studies ice morphology, statistics, and fundamental mathematical problems at the Geographic Institute of Copenhagen). Then, she takes part in various scientific expeditions all over Greenland and writes some scientific papers.

And I... who am I? Am I the scientist, the observer? ....Am I the one who has been given the chance to get a glimpse of life from the outside? ……From a point of view made up of equal parts ofloneliness and objectivity?.....[4]

They called her Smilla because, as soon as she was born she smiled to her father…

Smilla.. is merely a sound . If you look beyond the sound, you will find the boby with its circulation, its movement of fluids. Its love of ice, its anger, its login, its knowledge about space, its weakness, faithlessness and loyalty. Behind these emotions the unnamed forces rise and fade away, parcelled-out and disconnected images of memory , nameless sounds . And geometry. Deep inside us is geometry. My teaches at the university asked us over and over what the reality of geometric concepts was. They asked: Where can you find a perfect circle , true symmetry, an absolute parallel when they can't be constructed in this imperfect , external world? I never answered them, because they wouldn't have understood how self-evident my reply was, or the enormity of its consequences. Geometry exists as a innate phenomenon in our consciousness. In the external world a perfectly formed scow crystal would never exist. But in our consciousness lies the glittering and flawless knowledge of perfect ice. If you have strength left, you can look further, beyond geometry, deep into the tunnels of light and darkness that exist within each of us, stretching back toward infinity. There's so much you could do if you had the strength [5]

Smilla has a strong need to be alone, as every other Greenlander:

I feel the same way about solitude as some people feel about the blessing of the church. It's the light of grace for me. I never close my door behind me without the awareness that i am carrying out an act of mercy toward myself. Cantor illustrated the concept of infinity for his students by telling them that there was once a man who had a hotel with an infinite number of rooms , and the hotel was fully occupied. The none more guest

[4] Høeg P., *Smilla's sense of snow* : *A Novel* , translated by Tiina Nunnally.,. Farrar, Straus and Giroux, New, York, 1993, pp.234

[5] Ibid, pp. 300-301. What in this passage is expressed around the geometry poses a problem discussed on several occasions in the history of ideas, from the Presocratics to Plato, Aristotle, Descartes, ..., recording different emphases. The conception of space and geometry, which is the reading key, is no trace in many of the world's literature pages.

arrived. So the owner moved the guest in room number 1 into room number 2; the guest in room number 2 into number 3; the guest in 3 into room 4, and so on. In that way room number 1 became vacant for the new guest. What delights me about this story in that everyone involved, the guests and the owner, accept it as perfectly natural to carry out an infinite number of operations so that one guest can have peace and quiet in a room of his own . That is a great tribute to solitude.[6]

Her love for loneliness affects her relationship with others:

You can learn something about your fellow human beings from what they write in the margin. People have speculated a great deal about Fermat's vanished proof. In a book concerning the never-proven postulate that whereas it is frequently possible to divide the square of a number into the sum of two other squares, this is not possible with powers higher than two, Fermat wrote in the margin: "I've discovered a truly wonderful proof for this argument. Unfortunately, this margin in too narrow to contain nit.[7]*"…. I'm not perfect. I think more highly of snow and ice than love. It's easier for me to be interested in mathematics than to have affection for my fellow human beings. But I am anchored to something in life that is constant. You can call it a sense of orientation ; you can call it woman's intuition ; you can call it whatever you like. I'm standing on a foundation and have no farther to fall. Il could be that I haven't managed to organize my life very well. But I always have a grip-with at least one finger at a time-on Absolute Space. That's why there's a limit to how far the world can twist out of joint, and to how badly things can go before I find out.....*[8]

Smilla suffers from claustrophobia. From the words she uses to explain her fear to her friend the mechanic, who has a substantial role in the narration, her vision of life and her love for numbers emerge:

"Do you know what the foundation of mathematics is?" I ask. "The foundation of mathematics is numbers. If anyone asked me what makes me truly happy, I would say: numbers. Snow and ice and numbers. And do you know why?" ….. "Because the number system is like human life. First you have the natural numbers. The ones that are whole and positive. The numbers of a small child. But human consciousness expands. The child discovers a sense of longing, and do you know what the mathematical expression is for longing?….. "The negative numbers". The formalization of the feeling that you are missing something. And human consciousness expands and grows even more, and the child discovers the in between spaces. Between stones, between pieces of moss on the stones, between people. And between numbers. And do you know what that leads to? It leads to fractions. Whole numbers plus fractions produce rational numbers. And human consciousness doesn't stop there. It wants to go beyond reason. It adds an operation as absurd as the extraction of roots. And produces irrational numbers." … "It's a form of madness. Because the irrational numbers are infinite. They can't be written down. They force human consciousness out beyond the limits. And by adding irrational numbers to rational numbers, you get real numbers." I've stepped into the middle of the room to have more space. It's rare that you have a chance to explain yourself to a fellow human being. Usually you have to fight for the floor. And this is important to me. "It

[6] pp. 149-150..To observe that sometimes appear in scientific imprecisions. The example of "endless rooms" is by David Hilbert to give meaning to Cantor's theory of infinite.

[7] The reference is to " Fermat's Last Theorem, "which is not a" postulate "as is said here. It can be expressed in the following way: taken the natural numbers x, y and z, it is possible to verify that x ^ n + y ^ n = z ^ n, for all n> 2? The answer to this question takes place in the nineties by the British mathematician Andrew Wiles.

[8] Ibidem, pp. 26-27

doesn't stop. It never stops. Because now, on the spot, we expand the real numbers with imaginary square roots of negative numbers. These are numbers we can't picture, numbers that normal human consciousness cannot comprehend. And when we add the imaginary numbers to the real numbers, we have the complex number system. The first number system in which it's possible to explain satisfactorily the crystal formation of ice. It's like a vast, open landscape. The horizons. You head toward them and they keep receding. That is Greenland, and that's what I can't be without ! That's why I don't want to be locked up." [9]*.... There's no simple arithmetic for life's distribution of happiness and sorrow, no such thing as a standard share.....We all have our limits. A certain limit to our perseverance, to how many overtures we can make in our lives. And to how many rejections we can stand*[10]*... Infatuation always simplifies things. Like mathematics*[11]

During her education she learns what scientific method is and how it works; during her scientific expeditions she is able to prove its effectiveness. During the course of the narration Smilla employs it to solve an everyday life problem.

Throughout the novel the reader can find hints at the history of the scientific method, that can be traced back to Euclid's Elements (book that she reads over and over), to the history of mathematics, and of other sciences. A certain importance assumes also its evolution over the centuries (quite interesting is her relationship with Newton), and its social role in helping gaining scientific knowledge. Euclid and Newton are explicitly mentioned for having contributed to the formulation of this method.

Euclid's Elements in her education and studies. Euclid plays a part since the very first encounter between Smilla and Esajas, who live in the same apartment complex on different floors. It is a sultry day in Copenhagen.

It's the kind of day that might make you wonder about the meaning of life, and discover that there is none. And there's something rooting around on the stairway, on the landing below my apartment.....For a moment I think it's a dog lying on the stairs. Then I see that it's a child, and on this particular day that is not much better. "Beat it, you little shit," I say. Isaiah looks up. "Peerit," he says. Beat it yourself. ....."Will you read me a story?" I have a book in my hand. That's what prompted his question. You might say that he looks like a forest elf. But since he is filthy, dressed only in underpants, and glistening with sweat, you might also say he looks like a seal pup. "Piss off," I say. "Don't you like kids?" "I eat kids." He steps aside. "Salluvutit, you're lying," he says as I go past. At that moment I see two things in him that somehow link us together. I see that he is alone. The way someone in exile will always be. And I see that he is not afraid of solitude. "What's the book?" he shouts after me. "Euclid's Elements," I say, slamming the door. It turned out to be Euclid's Elements, after all. That's the one I take out that very evening when the doorbell rings and he's standing outside, still in his underpants, staring straight at me; and I step aside and he walks into my apartment and into my life, never really to leave it again; then I take Euclid's Elements down from the bookshelf. As if to chase him away. As if to establish from the start that I have no books that would interest a child, that he and I cannot meet over a book, or in any other way. As if

[9] Ibidem, pp. 114-115
[10] Ibidem, pp. 408-410
[11] Ibidem, pp. 425. The research of loneliness and claustrophobia accompany the lives of many mathematicians, as we know. In the passage quoted is given a beautiful image of mathematics, in which the expansion of the numbers is read as the transition from a "desire" of consciousness to another, These desires come more and more deeply until you get to that satisfied by "complex numerical systems": "the first number system in which it is possible to give a satisfactory explanation of the formation of ice crystals ... it's like a great open landscape ...". Thus we enter into the heart of the interests of Smilla.

to avoid something. We sit down on the sofa. He sits on the very edge, with both legs crossed, the way kids from Thule used to sit at Inglefield in the summertime, on the edge of the dogsled used as a bed inside the tent. "A point is that which cannot be divided. A line is a length without breadth." This book turns out to be the one he never comments on, and the one we keep returning to. Occasionally I try others. One time I borrow the children's book Rasmus Klump on the Ice Cap. In all serenity he listens to the description of the first pictures. Then he points a finger at the toy like bear Rasmus Klump. "What does that one taste like?" he asks. "A semicircle is a figure contained within a diameter … and the circumference intersected by the diameter." For me, the reading goes through three phases on that first evening in August. First there is simply irritation at the whole impractical situation. Then there is the feeling that always comes over me at the mere thought of that book: veneration. The knowledge that it is the foundation, the boundary. That if you work your way backwards, past Lobachevski and Newton and as far back as you can go, you end up at Euclid. "On the greater of two given unequal straight lines …" Then at some point I no longer see what I'm reading. At some point there is only my voice in the living room and the light of the sunset from the South Harbor. And then my voice isn't even there; it's just me and the boy. At some point I stop. And we simply sit there, gazing straight ahead, as if I were fifteen and he were sixteen, and we have reached "the point of no return." Sometime later he gets up very quietly and leaves. I watch the sunset, which lasts three hours at this time of year. As if the sun, on the verge of leaving, had discovered qualities in the world that are now making its departure a reluctant one. Of course Euclid didn't scare him off. Of course it made no difference what I read. For that matter, I could have read aloud from the telephone book. [12]

Newton's role in her education and life. She has a unique relationship with Newton and talks about him in an enthusiastic tone:

My only spiritual brother is Newton. I was moved when, at the university, they introduced us to the passage in Principia Mathematica, Book One, where he tips a bucket full of water and uses the tilted surface of the water to argue that there is Absolute Space inside and surrounding the rotating earth and the turning sun and the tumbling stars, which makes it impossible to find any constant starting point or initial system or fixed point in life. Absolute Space - that which stands still, that which we can cling to. I could have kissed Newton. Later I despaired over Ernst Mach's criticism of the bucket experiment, the criticism which formed the basis for Einstein's work. I was younger then and more easily moved. Today I know that all we did was prove that Newton's arguments were inadequate. Every theoretical explanation is a reduction of intuition. No one has budged my or Newton's certainty about Absolute Space. No one is going to find his way home to Qaanaaq with his nose stuck in Einstein's writings.[13]

The relationship between experience and knowledge, the idea of progress and technological culture, the relationship between science and life. In the context of the scientific method some problems arise concerning the relationship between experience and knowledge, neocatastrophism, technological culture, the relationship between science and life, …

[12] Ibidem, pp. 13-15. This quote shows how one can speak lightly of deep feelings, moods and needs of the spirit, even through very specific references to the Euclidean text.

[13] Ibidem, p. 44. We believe that an interest in mathematical principles of natural philosophy of Newton, for criticism from Mach and for overcoming the Newtonian vision by Einstein must mark all educational routes of secondary school. In addition, the problems presented in this step and the next, are extremely topical in contemporary culture

The following words explain what the relationship between experience and knowledge is:

According to a certain scientific theory you can only be sure of the existence of what you yourself have experienced.[14]

During a conversation with her father Smilla asks him what neocatastrophism is. The answer she receives is:

"Neocatastrophism is a collective term. It was coined by Schindewolf sometime in the sixties. He was a palaeontologist. But all kinds of scholars in the natural sciences have taken part in the debate. What they agree on is that the earth— and, in particular, its biology— has not evolved at an even pace but in leaps, which have been directed by great natural catastrophes that favour the survival of specific species. Meteor showers, comets, volcanic eruptions, spontaneous chemical disasters. The core of the debate has always been the question of whether these catastrophes occur at regular intervals. And if they do, what determines the frequency? An international association was established. Their first meeting was in Copenhagen. At the Falkoner Conference Center. Opened by the Queen. They spared no expense. They get money from left and right. The unions contribute because they think it's research about environmental disasters. Those in the industrial sector contribute because they think that at least it's not about environmental disasters. The research councils contribute because the association has some big names to flaunt."[15]

Before the big floating pier Greenland Star, off the coast of Nuuk, a remark is uttered that conveys her idea of technological culture:

"It has all been created with the goal of coercion in mind. Not the coercion of Greenlanders. The presence of the army and the direct violence of civilization are almost at an end in the Arctic. It's no longer necessary for development. The liberal appeal to greed in all its aspects is sufficient today. Technological culture has not destroyed the peoples of the Arctic Ocean. Believing that would be to think too highly of culture. It has simply acted as a catalyst, a cosmic model for the potential— which lies in every culture and every human being— to center life around that particularly Western mixture of greed and naiveté. What they want to coerce is the Other, the vastness, that which surrounds human beings. The sea, the earth, the ice. The complex stretched out in front of us is an attempt to do that".[16]

Finally, Smilla reflects upon the relationship between science and life:

"We all live our lives blindly believing in the people who make the decisions. Believing in science. Because the world is inscrutable and all information is hazy. We accept the existence of a round globe, of an atom's nucleus that sticks together like drops, of a shrinking universe and the necessity of interfering with genetic material. Not because we know these things are true, but because we believe the people who tell us so. We are all proselytes of

[14] Ibid, p. 57

[15] Ibid, p. 182. How much irony in the final expressions! Certainly cannot leave indifferent those who evaluate the facts and events of our day also

16 Ibid, p. 360. The environmental activists and ecologists found this passage a "their" expression. On the other hand we find here and in other passages shared indications of new cultural and scientific routes that to be taken, giving clear answers about the use and usefulness of science, scientific research, the development of scientific knowledge, ...

science. And, in contrast to the followers of other religions, we can no longer bridge the gap between ourselves and the priests....." [17]

Our reading of the novel ends here.

The above mentioned passages induce a reflection on the role of a "scientific" method in the interpretation of facts and events of life. Other perspectives can be adopted to read the same passages.

The reference to this novel as a "literary product" is not merely functional to our reflection on the "method", it testifies our commitment to restore the cultural value of mathematics and other sciences, especially within the Western paradigm.

Science teachers are not only "versed" in "arcane" knowledge; they promote a close dialogue with the culture of their time, proving themselves an essential part of it, and promoting a synthesis among different fields of knowledge.

3. From a reading of the novel to some reflections on the history of scientific "method"

The perspective adopted to read this novel allows us to pose some questions. What is the role of scientific education in our life? Is there a marked dualism between humanities and scientific culture? How comes that many students when dealing with the teaching of mathematics, physics, biology, chemistry, …, seem to have a loose grasp of these disciplines?

Within the novel we find a concrete example of how these disciplines help conveying a vision of life where the pursuit and application of a behavioral "method" are an expression of personal identity.

In teaching these disciplines, a fundamental problem lies in the method employed by everyone of them.

Today the term "method" is abused even in everyday language. We would like to point out that this term does not imply any kind of constraint or limit to fantasy and freedom, nor it is the outcome of a mere self-interested calculation.

Method is the ability to combine rationality and intuition, intellectual activity and impulse of the heart, "esprit de finesse" and "esprit de géométrie" (Blaise Pascal).

Let us make some considerations on the history of the "scientific method", being careful to choose ideas and concepts strictly connected to the educational background of our audience (high school students).

Young René Descartes focuses at length on developing a "method" that could be useful in everyday life. In Rules for the Direction of the Mind (circa 1628) we find a specific indication: mathematical method is the one we need in everyday life. What kind of mathematics is he talking about?

[17] Ibidem, p. 429

Descartes points out that ideals of beauty and perfection associated to mathematics are not in fact pursued by "ancient" mathematicians. He wrote,

«it did not seem to me that they demonstrated to the spirit itself why things happened and how they were perceived»[18].

His criticism of classical mathematics is excessively harsh and does not match the historical truth, as we will be able to see in a while.

Shortly afterwards, he states that

« Consequently I was not surprised that many people, even of talent and scholarship, should, after glancing at these sciences, have either given them up as being empty and childish or, taking them to be very difficult and intricate, been deterred at the very outset from learning them. For really there is nothing more futile than to busy one's self with bare numbers and imaginary figures»[19].

How can one investigate the truth of life? Descartes deems analysis to be the most suitable method. It was employed by the ancients to solve all sorts of problems (not only mathematical problems) and he believes that in order to reach the truth, one does not only need to study mathematics, but also to gain knowledge of the "method" or of the "path", and by following it, one will be able to achieve the expected result.

He himself mentions the habit of early philosophers, actually described at a later time in history, who refused to teach philosophy to those who had not received a mathematical education – even though the mathematics they referred to was quite basic. Descartes clarifies this point in his own terms:

«certain primary germs of truth implanted by nature in human minds»[20]

empowered so much the ancient men

«thus the same mental illumination which let them see that virtue was to be preferred to pleasure, and honour to utility, although they knew not why this was so, made them recognize true notions in Philosophy and Mathematics, although they were not yet able thoroughly to grasp these science» [21].

What is, then, mathematics? What is it about? What does it pertain to? Descartes answers these questions stating that:

«But as I considered the matter carefully it gradually came to light that all those matters only were referred to Mathematics in which order and measurement are investigated, and that it makes no difference whether it be in numbers, figures, stars, sounds or any other object that the question of measurement arises»[22].

[18] *Rule IV* of the *Regulae ad directionem ingenii*, René Descartes, *Opere postume 1650-2009.* Testo francese e latino a fronte. A cura di Giulia Belgioioso con la collaborazione di Igor Agostini, Francesco Marrone, Massimiliano Savini, Il pensiero Occidentale, Bompiani, Milano, 2009, pp. 702-703.
[19] Ibidem, pp. 702-703.
[20] Ibidem, pp. 704-705.
[21] Ibidem, pp. 704-705.

He further argues that:

«This furnishes us with an evident explanation of the great superiority in certitude of Arithmetic and Geometry to other sciences The former alone deal with an object so pure and uncomplicated, that they need make no assumptions at all which experience renders uncertain, but wholly consist in the rational deduction of consequences..... But one conclusion now emerges out of these considerations, viz. not, indeed, that Arithmetic and Geometry are the sole sciences to be studied, but only that in our search for the direct road towards truth we should busy ourselves with no object about which we cannot attain a certitude equal to that of the demonstrations of Arithmetic and Geometry»[23].

Mathematics is a fundamental discipline that provides learners with "certain knowledge" and shows the "path" to gain it. This "path" is the essential prerequisite to the study of science, from medicine to theology, from law and philosophy of nature to engineering, …

The attribution of this role to mathematics can be traced long back. Let us follow the course of the events leading to it.

Plato discusses at length the meaning of "science" and its "model". The «episteme» (that philologically assumes these meanings in sequence: knowledge, awareness, ability, competence, art, science) is neither an opinion nor a conjecture nor an assumption.

In the Republic the transition takes place from opinion to science, from doxa to episteme.

In the Teeteto it is debated if science is perception, opinion, genuine opinion accompanied by an explanation, reaching the conclusion that it is none of the above.

In the Epinomis mathematics is presented as the science

«that makes one really knowledgeable and not only appearing as such»[24].

It is the "fundamental science":

«without it humans would be the most inane and foolish beings». «It is the discipline that gave human kind numbers», through which it is possible to trace «the whole progression of motion in the sky»[25] .

In the Meno (specifically in the scene «Socrates and the slave boy») by means of a geometrical example (given a square, find a square with double surface area) the organization of knowledge through hypotheses is emphasized.

In the Posterior Analytics, Aristotle reflects upon science asserting that:

«we possess scientific knowledge of a thing when we know its cause»26;

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[22] Ibidem, pp. 706-707.
[23] Ibidem, pp. 690-693.
[24] *Epinomide,* 976 C, Platone, *Tutti gli scritti* a cura di Giovanni Reale, Rusconi, Milano, 1991, p. 1772b.
[25] Epinomide, *976D*, ibidem, p. 1773a.

«science gains knowledge through demonstration» expressed in the form of "scientific syllogism"[27]*;*

«demonstrative science proceeds from principles that are already known, immediate, antecedent and more certain than the conclusions derived from them»[28]*;*

«founding elements of science are definitions, axioms, and demonstrations»[29]*.*

These statements highlight different issues that today go together under the definition of "science epistemology".

In the Metaphysics the primacy of mathematics over other sciences is implicitly stated on account of its objects that are either tangible (whose domain is natural philosophy) or transcendental (whose domain is metaphysics) through a process of abstraction. Moreover, mathematics is associated to "beauty" and "goodness" since – despite never mentioning these – it is able to convey their quintessential meaning and outcomes. In particular, beauty finds its expressions in order, symmetry and definite configuration, all typical features of mathematics.

The epistemological structure of science, outlined by Aristotle in the Analytics, finds its first and fundamental description in Euclid's Elements (367 BC – 283 BC; active in Alexandria between 300 BC – 280 BC).

This explains the educational role this text had over the centuries, both within the Quadrivium, that included basic scientific notions (arithmetic, geometry, music, and astronomy) and in the new educational model outlined by Giorgio Valla in his posthumous work De expetendis et fugiendis rebus opus… (1501) where other disciplines appear such as economy, perspective, …

The Elements, as it unfolds, shows how the "geometrical" and "arithmetical" discourse should be organized. This arrangement, defined as "epistemological structure", makes mathematics the "model" for every other scientific discipline.

This appears clear in three different situations concerning medicine, theology, and law, all of which are classified as "science". We can mention:

(1) in the field of medicine, the epistemological reform proposed by Galen of Pergamon, who in Quod Optimus Medicus Sit quoque Philosophus and in Istitutio Dialectica establishes the primacy of Aristotle's logic within medical education and proposes demonstrations/reasoning of geometrical type;
(2) the discussion about theology and whether it can be considered a science, which took place among academics of Oxford and Paris universities and which was resumed between the XVII and the XVIII century in the context of the debate about the mathematical method30.

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[26] *Second Analytiques*, *Chapitre II*, Aristote, *Seconds Analytiques*. *Organon IV*, Presentation et tradition par Pierre Pellegrin, GF Flammarion, Paris, 2005, pp. 66-67.
[27] Ibidem, pp. 66-67.
[28] Ibidem, pp. 66-69.
[29] Ibidem, pp. 70-71, 114-117..
[30] See the excellent book by Marie-Dominique Chenu, 1957 (The théologie science comme au XIIIe siècle, Paris, Librairie Philosophique Vrin, 1957). This volume, though dated, is still enlightening. The fundamental problem is also addressed in more recent studies of Funkenstein 1986 (Theology and the scientific imagination, Princeton, Princeton University Press, 1986), Jaki 1989 (God and the cosmologists, Edinburg, Scottish Academic Press, of the Polkinghorne 1986 (One world: the interaction of science and theology, London, SPCK, Trinity Church)

(3) the logic of law, as we read in Cicero's Ad Trebianum Topica and in the Digesta of the Codex Justinianus, and later in some treatises published between the XVI and the XVII century31.

Starting from the XVII century, natural philosophy and optics, always considered scientific disciplines, are organized and founded upon "sensible experiences" and "certain demonstrations".

Between the XVI and the XIX century in addition to mathematics and its multiple expressions (geometry, arithmetic, analytical geometry, algebra, …) studies on the possibility/probability of events gain importance and, later, on the frequency of events and their statistical study.

In particular, throughout the XVII century, the question arises as to whether it is possible to read the reality and circumstances of human life by means of mathematical strategies and employing elements of numerical prediction. A few examples are:

(1) in the writings of George-Louis Leclerk, Comte de Buffon(1707-1788), in relation to the classification of plants and flowers and to the genesis of living beings.
(2) Etienne Bonnot de Condillac(1715-1780), in relation to the study of events, elective assemblies, and of perception.
(3) Thomas Robert Malthus(1766-1834), in relation to the prediction of population development in a state, …

In the same period, knowledge in the field of acoustics is gained, magnetism and electrostatics are developed, and finally electromagnetism and James Clerk Maxwell's equations take shape.

Biology and chemistry are organized and systematized as scientific knowledge as well. Moreover, a new impulse is given to the study of economic and social phenomena, to psychology, psychiatry, …

At the same time industrial development poses constant demands to science for the development of new solutions concerning, for example, the possibility of transforming coal into useful work through combustion, or the need for effective industrial machines.

In the XIX century a major development occurred in the field of physics and the work of physicists allows to answer many questions and address many challenges.

These are only a few examples that show how in the West new scientific disciplines came to existence, while the old ones underwent major developments. An in-depth, multidisciplinary analysis would certainly highlight the existing connections between the events described.

In the attempt to attribute the status of scientific discipline to many branches of knowledge, which one do we use as a paradigm? Mathematics? Physics that is responsible for major economical and industrial developments as well?

[31] See Legalis dialectica PA Gammarus (Bologna, 1524), Books Dialecticae legalis quinque Ch. Hegendorphius (Leipzig, 1531), Topica legalis C. Cantiuncula, aka Chansonette (Basel, 1545), Topicorum legalium ... traditio J. Oldendorpinus (Marpurg, 1551), the lawiers logiké A. Fraunce (London, 1588), De logical jureconsultorum J. Th duo books. Freigius (Basel, 1590), logic juridica M. Schichhardus (Herbornae Nassaviriorum, 1615), Demonstratio logicae verae juridica C. Regnerus (Leyda, 1638).

It must be noted that starting from the second half of XIX century mathematics shows an increasing level of formalism, moving from playing a key role as a language in the interpretation of reality to a new status where the distance between reality and mathematical expression gradually increases to become an unbridgeable gap.

At the same time, disciplines where observation of phenomena and experiments play a major and even critical role, employ scientific methods which tend to move towards a practical approach of "doing physics" and away from "doing mathematics".

For these disciplines the "doing" of physics becomes the reference model from a double perspective:

(1) studying phenomena or facts pertaining to disciplines that rise to the status of science by adopting the same method and point of view that physics employs towards its subject matter (in philosophical terms this is called "ontological monism").

This is observable in the history of psychology which was since the very beginning classified as an "applied" discipline. Experiments play, then, a fundamental role and psychological phenomena are studied and analyzed as if they dealt with "physical" reality. For example, many psychological phenomena are studied and evaluated in terms of relationship between concurring energies or opposing forces; the same properties of electromagnetic fields are attributed to the area of influence of psychological phenomena.

Plenty of evidence can be found, in this sense, throughout the history of psychiatry, mental institutions, and in the therapies adopted. A mention must be also made of Cesare Lombroso's studies, that associated criminal tendencies with the offender's cranial shape. We must keep in mind that not a long time ago "psychological" phenomena were studied almost exclusively as "neurological" phenomena.

(2) Retaining for every discipline the peculiar nature of its phenomena, but, at the same time, analyzing these phenomena by means of the "method" employed in physics, where the relationship between experiments and their explanation-interpretation is so close to become a proper demonstration (in philosophical terms this is called "methodological monism"). Therefore, other disciplines adopt the method used in physics still retaining their specific contents. This tendency can be observed clearly in sociology and economy since the second half of XIX century.

Between the end of XIX century and the first decades of XX century, relativistic and quantum mechanics call into question many assumptions of classical physics with the introduction of uncertainty principle and the passage from simple to complex systems, …

In the same period, many disciplines claim the status of science and call for criteria that could be more lenient compared to those already established (rigor, certainty, and truthfulness of demonstrations). Even though there is never an explicit assertion or "postulation" of this need, a certain leniency is required to compensate the "rigor" – intended as the logical relationship between premises and consequences – and the "objectivity" – intended as "shared knowledge".

In the meantime, the concepts of "theory" and "scientific theory" are debated at large.

Should a "theory" be considered in itself and/or depending on its usefulness? Similarly, the meaning of "progress" and "scientific progress" is expanded.

A "reasonable" usage of the acquired knowledge is, nevertheless, always privileged. The widespread usage of the terms "model" and "modeling" emphasizes two different aspects: on one hand the search for real "development models" that could help in getting a better understanding of multiple events of our complex reality; on the other the superficial usage of these two terms in order to explain everyday life events.

4. Conclusions

Our starting point was the reading of the novel Miss Smilla's Feeling for Snow, where we traced the main character's upbringing, which is relevant for her existence. This was the premise to our reflection on the "scientific method".

We pointed out a close connection between the two parts. Now, to many this connection might look obscure, as well as the first part might be considered irrelevant in order to present the second.

For us and for those who attended, this was a "useful" educational experiment, where literary "stimuli" were combined with scientific reflection, and which induced a reflection on our knowledge and on what it really represents in our life. This union of disciplines stressed the need to analyze the relationship between the two "cultures": "humanities" and "science".

Considering the choices made in presenting this topic and the good results obtained with our experiment, it is possible to state that the approach we chose enables people with a specialized knowledge in mathematics, physics, biology, literature, philosophy, …, to be receptive to multiple disciplines, from literature to philosophy and science, many fields of science…

This inevitably leads to overcoming the distinction between humanities and science, to give birth to culture tout court.

And as a consequence professional choices of everyone should be read within a wider cultural context, where every specific educational path is marked by its peculiar features.

The availability of multiple educational paths to propose and/or choose from, requires to establish clear and precise goals. Identifying the peculiarities of all the different paths means identifying their limits and potential.

This vision, therefore, proves to be extremely effective and significant from the educational point of view.

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