Math fiction novels and their interdisciplinary didactic potential

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Abstract. On the basis of the connection between Mathematics and Literature, this article describes an experience of interdisciplinary teaching created using selected math fiction novels. Moving from previous studies on the subject (Kasman 2003, Padula 2005), this paper aims at providing interdisciplinary didactic units to allow students to deal with diverse areas of knowledge, ranging from English Language and Literature to Mathematics in an interdisciplinary perspective. The lesson, which constitutes the core of this work and is described in the last part of this work, was held in the Class IV of the Scientific High School 'Mancini' in Avellino, Italy, as part of the project 'Liceo Matematico' (Math High School) promoted by the Department of Mathematics at the University of Salerno, Italy (Capone et al. 2016). The corpus of works chosen from the Mathematical Fiction genre written in English, namely Abbott's Flatland (1884), Aldous Huxley's Young Archimedes (1924) and Stewart's Flatterland (2001), proved to neatly fit the lesson planned.

1. Introduction

When *genius meets rules* a dichotomy is served. This is true for those who conceive art, in which literature is included, as an ephemeral embodiment of human sake for pleasure. But it is not always 'art for art's sake', to speak with Wilde. More so, when we consider the literary genre known as Mathematical Fiction, in which the scientific *mentis* of the authors creatively entwines with their literary attitudes to produce novels that reverse the opening dichotomy and assert the beauty of a rigorous thinking within a humanistic scaffold. It has been widely proven how the 'two cultures' (Snow 1959) - science and humanities - not only can coexist, but fruitfully enlarge each other's horizon. From a didactic viewpoint, novels from the Maths Fiction genre proved to be a challenging, at times puzzling starting point to trigger highly captivating, interdisciplinary lessons within the Maths and Literature module.

2. Popular math fiction novels

If we consider the Math Fiction genre as a corpus of all the works in which mathematics is involved, then its birth can be dated back to the Ancient Greek, when mathematical issues were addressed through a Pythagorean harmony which flew into seas of pleasing knowledge. According to Professor Alex Kasman from the College of Charleston, who maintains a database of mathematical fiction works, the first book of the genre is *The Birds*, a comedy written in 414 BC by the Ancient Greek playwright Aristophanes. The list goes on by sorting, among the others, Chaucer, Swift, Mary Shelley, Carroll, Conan Doyle and, more than once, H.G. Wells and Poe.[1] Mathematics and mathematicians have also starred novels which have been adapted into movies, let us think to *A Beautiful Mind*, from the homonym book by Sylvia Nasar on the life of the Nobel prize mathematician John Forbes Nash, or *The Theory of Everything*, from the memoir *Travelling to Infinity: My*

[1] For the whole list see http://kasmana.people.cofc.edu/MATHFICT/mfbrowse-pubyear.php [accessed on July 2, 2019]

Life With Stephen by Jane Hawking, who gives an account of her life with her ex-husband, the theoretical physicist and cosmologist Stephen Hawking. As for TV series which pivot on mathematics can be mentioned *Numb3rs* and *Freaks Geeks*. Back to literature, one of the earliest novels entirely built on a scientific, mathematical plot is *Flatland: A Romance of Many Dimensions*, “a work of scientific fantasy written by the English clergy-man and headmaster Edwin Abbott Abbott and published in 1884” (Abbott & Stewart 2002, p. ix). Janice Padula (2005, 7) notes how “the book is a guide to the geometry of space-time and relativity, and a clever social commentary (Renz, 2002) [which] introduces more up-to-date dimensions of space-time, up to a ten-dimensional super manifold (Collins, 2004).” As Ian Stewart, Professor of Mathematics at the University of Warwick and Director of its Mathematics Awareness Centre, remarks in the Preface of *The Annotated Flatland* (2002), the book

> is a charming, slightly pedestrian tale of imaginary beings: polygons who live in the two-dimensional universe of the Euclidean plane. Just below the surface, though, it is a biting satire on Victorian values — especially as regards women and social status — and an accomplished and original piece of scientific popularisation about the fourth dimension (Abbott & Stewart 2002, ix).

Stewart is also the author of a *Flatterland* (2001), a modern version of *Flatland*, which tells the story of Vikki, the great-great-grand-daughter of A. Square, who, after deciphering some pages of *Flatland*, is visited by Space Hopper and invited to visit *Mathiverse*, a world of higher dimensions. The book “contains descriptions of non-Euclidean geometries from topology to projective and fractal geometries, and conversational, question-and-answer explanations of phenomena such as black holes — regions of space-time from which nothing, not even light, can escape.” (Abbott & Stewart, 2002). The book is reasonably regarded by many as a sequel of Abbott’s *Flatland*, whilst, as Jodi Trout maintains,

> There is so little to do with Flatland itself, except for the handful of miniscenes where Vikki’s family mopes about her absence, and Vikki so quickly begins to talk and act like a 3D human (seeming to know several obscure facts of human science and history) that there really was no need to set it in Flatland to begin with. (Trout 2002, 463).

Another brilliant work attributable to the genre is Aldous Huxley’s short story *Young Archimedes* (1924), a bitter-sweet short story about a 7-year-old boy prodigy fascinated by music, numbers, symmetry and the Pythagorean Theorem. And yet, a tale of wasted talent.

3. Math and literature: towards an interdisciplinary didactics

The issues and ideas arising from the above-mentioned books establish a tight connection between literature and mathematics, a field of reciprocal contamination which paves the way to an educational approach based on an interdisciplinary perspective, escaping the didactic fragmentism and endorsing the laboratorial experience. Professor Kasman proposes an interdisciplinary course which, pursuing the main objective of teaching Mathematics, is based on a selected *corpus* of mathematical fiction books - extracts, short stories and full books - to be read and discussed with an interdisciplinary class. Interesting is how Kasman aims at creating a debate so that “students would be free to pursue their own interests and use the techniques from their own area of expertise.” (Kasman

2003:2). His approach confirms how humanism and mathematics, both rational philosophies, enhance each other and further the construction of a critical thought which constitutes, especially for high school and university students, a fundamental achievement. The interest of students or scholars from the most diverse fields of education can be triggered and shaped into a cohesive and multifaceted school or university program (Kasman 2003:6). Indeed, it is through critical thinking that the knowledge and the skills of a person can be measured and eventually broaden. In some ways, this splitting of the class into groups of interest recalls Elliot Aronson's didactic technique known as *Jigsaw*, which established that a collective task can be efficiently accomplished through individual commitment (Aronson 1978). Of extreme importance for both strategies is the reinforcing of the awareness of each student's importance in the process of learning and the advantages of *cooperative working*[2]. Janice Padula, professor of Math and Science at the Clinton Community College of Burlington, USA, endorses the advantages of an interdisciplinary, mathematical based lesson by stating that the use of math fiction novels

> may stimulate the interest of reluctant mathematics learners, reinforce the motivation of the student who is already intrigued by mathematics, introduce topics, supply interesting applications, and provide mathematical ideas in a literary and at times, highly visual context. They are a way of humanising mathematics and introducing topics in an engaging and accessible frame. (Padula 2005:13)

On this basis, the lesson here proposed points at confirming the cooperative and interdisciplinary approach as in Kasman and Padula, but reversing the perspective and giving to English language and literature the starring role. In other words, if Kasman proposal pivots around the question "What is mathematics? What do mathematicians do and what is their role in society? What do authors think the answers to these questions are?" (Kasman 2003:2), the following lesson would start by asking students "What is math fiction? How authors of this genre use mathematic themes to shape literary plots? How would they use language to amuse readers and, in the meantime, edify them about scientific issues?". Accordingly, *Flatland*, *Flatterland* and *Young Archimedes* constitute the primary sources selected for the lesson held in the Class IV of the Scientific High School 'Mancini' in Avellino, Italy.

4. The lesson

The lesson started by writing on the blackboard the word *consonance*. The guided debate which followed, took a 'super manifold' direction. Firstly, the whole class proceeded by reflecting on a suggested simile, namely how intricate literary plots reflect complex arithmetic expressions: think of a crime novel in which the solution of the case is achieved through different phases of investigation, more and more complex, as in arithmetic we would first solve the operations in round brackets/evidence collection, then in square brackets/check the alibi, and finally in braces/unmask the culprit. When questioned about poetry, the connection became less fanciful and the students agreed on the visible use of structural parameters, as the *consonance* used to build rhymes in the poem *Numbers* by Lawrence Binyon (1922:94) which students read on the handout provided:

[2] On cooperative working see West, M. A., et.al., 2008, *International handbook of organizational teamwork and cooperative working*. In the Italian academic scenario, the binomial Literature and Mathematics has been recently discussed in Capone, R., Pace, G., Tortoriello, F. S., 2017, *Mathematics and Literature in Secondary School: an interdisciplinary teaching proposal*, Quaderni di Ricerca in Didattica, Vol. 27. p. 39-47.

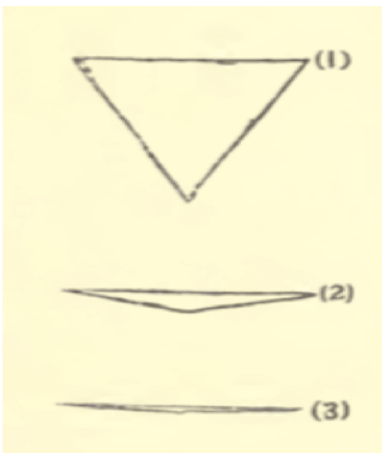
Bodiless Numbers! . . .
O inhuman numbers! ...
Are you masters or slaves —
Subtlest of man's slaves, —
Shadowy Numbers?

Here, the term *consonance*, sparked interesting reflections on its different but convergent acceptations: as a literary device, it refers to the use of similar consonants, as in *Fair is Foul, Foul is Fair* in Shakespeare's *Macbeth* (here it is opposed to *assonance*); in music, it describes pleasant and agreeable intervals (opposed to *dissonance*); according to Pythagoreans, consonance and dissonance constitute mathematical concepts used to describe the *harmony* of a musical interval, harmony which, together with arithmetic, geometry and astronomy, was one of the founding elements of the *Quadrivium,* what today we call mathematics.

Once the contamination between the different fields had been ascertained, a bit baffled, but equally fascinated, students were prepared to start the proper lesson by analysing the extracts from the three books selected. The first book to be analysed was *Flatland*, whose characters and themes were introduced by a brief exercise asking students to match the words *Square*, *Polygons*, *Euclidean plane* and *Fourth dimension* with their definition. Indeed, the book tells the story of A. Square, a polygon who lives on a 2-D Euclidean plane, whose perspective is broaden to further dimensions after meeting a 3D Sphere. Then, the first selected excerpt was read:

> Nothing was visible, nor could be visible, to us, except Straight Lines; and the necessity of this I will speedily demonstrate. Place a penny on the middle of one of your tables in Space; and leaning over it, look down upon it. It will appear a circle. But now, drawing back to the edge of the table, gradually lower your eye (thus bringing yourself more and more into the condition of the inhabitants of Flatland), and you will find the penny becoming more and more oval to your view; and at last when you have placed your eye exactly on the edge of the table (so that you are, as it were, actually a Flatlander) the penny will then have ceased to appear oval at all, and will have become, so far as you can see, a straight line. (Abbott 1884:4)

Here, the first visible issue to be considered is perspective. While reading, the whole class followed the instructions provided and placed a coin on their table, proving the passage from a figure to a straight line due to perspective change, which Abbott - as reported in students' handout - illustrated as follows (Abbott 1884:4):



The kinetic reading of the extract, served as a gateway to the elicitation of some key concepts. Firstly, students were asked about the historical frame in which the book was written, namely the Victorian Age, and the social implications the book refers to. In the quoted extract, Straight Lines and Polygons represented respectively women and men, the former having their actions hierarchically limited by the latter. Even more, if the perspective is reversed, a straight line is seen as a motionless, directionless, meaningless point. The passage from *Flatland* to *Flatterland* occurred through the reading of another brief extract, in which A. Square - protagonist and pseudonym of the author - is introduced by Sphere to the world of Knowledge, the Third Dimension, namely a non-Euclidean domain. Students were thus asked to compare Euclidean with non-Euclidean geometries - being them expert on the subject, it constituted a mere language exercise - before skimming through the book, particularly lingering on chapters 7, "Along the looking glass", which deals with projective geometry, and 14, "Down the wormhole", where Einstein's General Theory of Relativity is amusingly tackled:

> "...our old friend Alberteinstein — yes, the People who realized that light can behave like a particle — used that one simple fact as the basis of an entire theory of Spacetime. He called his theory 'Relativity'.
> "Because it said that everything was relative?"
> "Pretty much the exact opposite! The main thing to remember about Relativity," said the Space Hopper, "is that it's an extraordinarily silly name."
> "Then why use it?"
> "Historical accident," said the Space Hopper. "The Planiturthians are stuck with it. The whole point of Relativity is not that 'everything is relative' but that one particular thing — the speed of light — is unexpectedly absolute." (Stewart 2001:191)

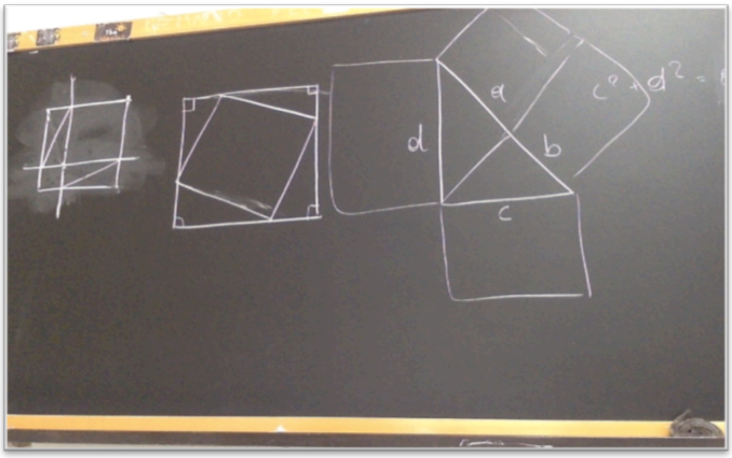
The above extract proved to be useful both to foster the interdisciplinary development of the lesson, as students were first asked to translate the text, and to quickly introduce students to Lewis Carroll's *Alice's Adventures in Wonderland* (1865) and its sequel *Through the looking glass* (1871), dense with mathematical issues, recalled by the titles of the above-mentioned chapters.

The last work to be analysed, Huxley's *Young Archimedes* (1922), was articulated around Euclidean geometry, translation and a laboratorial self-experimentation. The first excerpt provided was made of the first 6 pages of the book, skimmed through a driven reading to reveal the perspective play in describing the setting of the story, from the 'crests of the Apennines' to 'the little projecting terrace' facing 'the towered church of San Miniato, one saw the huge dome airily hanging on its ribs of masonry, the square campanile, the sharp spire of Santa Croce, and the canopied tower of the Signoria, rising above the intricate maze of houses, distinct and brilliant, like small treasures carved out of precious stones' (Huxley 1922: 273). Now that Florence had been uncovered, students were introduced to Guido, a seven-year-old mathematical prodigy, fascinated by Italian *Opera*, who demonstrates several proofs of the Pythagorean Theorem by using a burnt stick on cobblestones:

> I got up from my chair and looked over the balustrade to see what they were doing. I expected to catch them dabbling in water, making a bonfire, covering themselves with tar. But what I actually saw was Guido, with a burnt stick in his hand, demonstrating on the smooth paving-stones of the path, that the square on the hypotenuse of a right-angled triangle is equal to the sum of the squares on the other two sides. Kneeling on the floor, he was drawing with the point of his blackened stick on the flagstones. [...] A minute later Guido had finished both his diagrams. "There!" he said triumphantly, and straightened himself up to look at them. "Now I'll explain."

> And he proceeded to prove the theorem of Pythagoras — not in Euclid's way, but by the simpler and more satisfying method which was, in all probability, employed by Pythagoras himself. He had drawn a square and dissected it, by a pair of crossed perpendiculars, into two squares and two equal rectangles. The equal rectangles he divided up by their diagonals into four equal right-angled triangles. The two squares are then seen to be the squares on the two sides of any one of these triangles other than the hypotenuse. So much for the first diagram. In the next he took the four right-angled triangles into which the rectangles had been divided and rearranged them round the original square so that their right angles filled the corners of the square, the hypotenuses looked inwards, and the greater and less sides of the triangles were in continuation along the sides of the square (which are each equal to the sum of these sides). In this way the original square is redissected into four right-angled triangles and the square on the hypotenuse. The four triangles are equal to the two rectangles of the original dissection. Therefore the square on the hypotenuse is equal to the sum of the two squares — the squares on the other two sides — into which, with the rectangles, the original square was first dissected. (Huxley 1922: 317-320)

As happened with the coin 'deformation' in *Flatland*, the lesson proceeded on a dynamic, fully participated route. While a student was reading, all the classmates alternate at the blackboard, where squares, rectangles and triangles gave shape to Guido's words. All entirely and autonomously carried out by the students. The outcome is shown in the picture below:



The technique here used is transcodification, one among the fundamental techniques to guide and check students' comprehension, guaranteeing a clear pragmatic indication (Balboni 1998:75). More specifically, students performed the *Picasso Dictation*, a picture dictation which requires that a student provides the information, in the case in point by reading the whole extract from the story, to a classmate who executes the instructions, in a way, personifying little Guido. The technique just described helped students also to improve reading and listening skills of a foreign language, used as a vehicular language in a CLIL framework. This section took almost the whole second part of the lesson, but nonetheless, fascinated by the story and curious to discover the aforementioned sad ending, students asked to be led to the end of the story, finding how little Guido's talent for numbers and figures had been wasted when snatched from his needy family and adopted by *Signora Bondi*, a peasant landlady, whose vanity will keep the Young Archimedes far from ephemeral mathematic questions. The handout, and the lesson, ended with the teacher reading the closing lines of the story:

> In the Piazzale we halted for a moment to look down at the city in the valley below us. It was a day of floating clouds — great shapes, white, golden, and grey; and between them patches of a thin, transparent blue. Its lantern level, almost, with our eyes, the dome of the cathedral revealed itself in all its grandiose lightness, its vastness and aerial strength. On the innumerable brown and rosy roofs of the city the afternoon sunlight lay softly, sumptuously, and the towers were as though varnished and enameled with an old gold. I thought of all the Men who had lived here and left the visible traces of their spirit and conceived extraordinary things. I thought of the dead child. (Huxley 1922: 340)

4. Conclusion

By the end of the lesson, it was clear that the students had acknowledged the scientific, logical path on which math fiction novels are grounded, thus sharing with the mathematical thought a multifaceted, solid structure. In the same way, it has been recognized the high potential of the Mathematical Fiction genre as a source for interdisciplinary classrooms. Even more if the goal is shifted from the mere study of Mathematics to the study of a foreign language and literature, which continuously engage each other during a lesson.

The unusual investigation on these different subjects has made the task of the student harder, more complex, as he/she must demonstrate not only to have understood the topics he has been dealing with during the lesson, but also to be able to use the foreign language to actively participate in the classroom. As the *Picasso dictation* has proved, students have therefore been able to cope with the mathematical language, thanks both to their previous knowledge of the themes and to a lively cooperative work to get through the English text. More important, the type of activity proposed has enabled students to develop the critical thinking necessary for a successful participation and engagement in higher education environments. It would be advisable to think of an extended interdisciplinary teaching model which connect various branches of knowledge through the interaction of didactic pathways.

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