

Fiction and Philosophy of Science*

Paired Readings for the Science Classroom

Sumithra Surendralal

Writings that allow the reader to consider ideas in the sciences from different perspectives are of value both to students of the sciences and students from other disciplines. The construction and validation of models are central to knowledge generation in the sciences. Therefore it is worthwhile to spend time in the classroom developing student understanding of what models are, their usefulness, and their limitations. In this context, I suggest three texts that can complement a discussion on scientific models—two translated pieces of fiction by Jorge Luis Borges, *Funes the Memorious* (1942) and *On Exactitude in Science* (1946), and a philosophical essay by Arturo Rosenblueth and Norbert Wiener, *The Role of Models in Science* (1945).

Introduction

One of the fundamental assumptions of science is that the world is real and knowable by the observer. In trying to explain a phenomenon using a scientific approach, such an observer identifies features most significant to the phenomenon and their relations. Such a process necessarily implies excluding features and relations evaluated to be insignificant. Mexican physiologist Arturo Rosenblueth and American polymath Norbert Wiener¹, in *The Role of Models in Science* [1], refer to the process of constructing a simpler representative to stand in for the complex original as abstraction. They identify the representative as a model. Their 1945 essay dwells on the key aspects of working with models—abstraction and generalisation—essential for those engaging with



Sumithra Surendralal is an assistant professor at the Symbiosis School for Liberal Arts (SSLA), Pune, teaching courses in physics, mathematics, and general science. She works on modelling the syntax underlying behavioural sequences, such as animal vocalisations. She is also interested in conversations around pedagogy, particularly in the many versions of “The Two Cultures” debate and what they mean for the undergraduate classroom.

¹See *Resonance*, Vol.4, No.1 January 1999.

*Vol.28, No.7, DOI: <https://doi.org/10.1007/s12045-023-1637-x>



Keywords

Models, abstraction, generalisation, philosophy of science, fiction.

Engagement with ideas in the sciences through fiction can provide perspective.

the sciences to understand well.

In undergraduate classes where I teach students from across disciplines, I use *The Role of Models in Science* as primary reading material to discuss model construction and validation. Additionally, as secondary material, I use two of celebrated Argentine writer Jorge Luis Borges' writings—*On Exactitude in Science* [2] and *Funes the Memorious* [3]—works of fiction that deal with the idea that our mind navigates the world by making abstractions and generalisations. The two concepts are central to Borges' stories and provide an opportunity for students to think about abstraction and generalisation in contexts that are creative reimaginations of our everyday experience of the world. They are, therefore, excellent companions to the more formal considerations and language in *The Role of Models in Science*. Below I discuss each of the three texts and a few ways a teacher may use them.

Pedagogical Possibilities With *The Role of Models in Science*

Many topics of discussion in the science classroom and experiments in the laboratory implicitly assume a particular model. However, this is often not made sufficiently clear to students. For example, in physics lessons about the nature of light, students first study the classical pictures of light as a wave and light as a stream of particles. They are subsequently introduced to light as a stream of quantum mechanical entities called photons. Some of the confusion among students about what light is probably arises from not recognising that each of these pictures presents a distinct model. Therefore, a general introduction to scientific models and their evaluation based on how well they can account for observations is useful. In *The Role of Models in Science*, Rosenblueth and Wiener explain the production of scientific knowledge as a process that relies on constructing models at different levels of abstraction combined with making valid generalisations based on the understanding obtained from various models.

Models in the sciences are of different kinds. Some have material forms (shake tables to simulate earthquakes), some function



as analogies (flow of water through pipes as a model of electrical current), some are idealised (point particles, frictionless surfaces), and there are still other possibilities of categorisation. Rosenblueth and Wiener make the distinction primarily between formal and material models. Any structure that clarifies the logical relationship between relevant variables and a set of assumptions underlying the choice of variables is a formal or theoretical model. Material models, on the other hand, are tangible representations of a system.

Students invariably bring up tabletop volcanoes, the globe, and the map when asked for examples of material models. These examples present an opportunity to address the distinction between merely representational models and models used for scientific experimentation. A qualitative explanation of the different geometric projections needed to construct a spherical globe versus a map on a plane surface also helps clarify that material models must have an associated formal aspect. I discuss several other examples at this point and pose clarificatory questions. Why is it reasonable for scientists to consider the songbird a model organism for studying human speech? In what sense is it a 'model'? Rosenblueth and Wiener also allude to the use of model organisms in biological studies to explain how material models can be used for spatial and temporal scaling, i.e., the choice of smaller organisms for ease of experimentation and the choice of organisms that multiply rapidly in genetic studies for access to several generations of data in a short time. The discussion related to model organisms further helps emphasise that such choices cannot be made arbitrarily but must be accompanied by strong formal considerations.

Model categories can be, and are, contested [4], and the boundaries between categories in a taxonomy of models are admittedly fuzzy. However, I have found that a conversation around models in the classroom that directly addresses the fuzziness is of value to students. An engagement with *The Role of Models in Science* is an effective way to create a philosophical scaffolding that acquaints students with ways of thinking in the sciences. It is a discussion to which a teacher can periodically return to re-

The categorisation of models can be contested, but the attempt itself is a valuable pedagogical tool.



mind students about studying the production of scientific knowledge in the context of models and their usefulness and limitations. The essay was written in 1945, well before computational models were widely used in the sciences. So a discussion about the progression of types of models in the years since is also possible. The primary purpose of the reading would be to develop an understanding of the slippery notions of abstraction and generalisation, which are often assumed and not made explicit.

Abstraction as a Theme in *On Exactitude in Science*

Students typically associate the word ‘abstraction’ with something vague. “This is quite abstract” is often used colloquially to mean something obscure and complex, with a hint of an understanding of the thing being referred to as possessing an element removed from sensory experience. A more precise understanding of abstraction as an act of deliberate simplification is essential to develop.

Abstraction is an act of deliberate simplification.

On Exactitude in Science is a one-paragraph piece of writing by Borges presented as an entry in a travel book. The entry discusses an empire whose cartographers, in the process of improving their maps, create one that is as large as the empire itself in which there is a one-to-one correspondence between actual and mapped locations [3]. The piece is so short that I am reproducing it here.

“...In that Empire, the Art of Cartography attained such Perfection that the map of a single Province occupied the entirety of a City, and the map of the Empire, the entirety of a Province. In time, those Unconscionable Maps no longer satisfied, and the Cartographers Guilds struck a Map of the Empire whose size was that of the Empire, and which coincided point for point with it. The following Generations, who were not so fond of the Study of Cartography as their Forebears had been, saw that that vast Map was Useless, and not without some Pitilessness



was it, that they delivered it up to the Inclemencies of Sun and Winters. In the Deserts of the West, still today, there are Tattered Ruins of that Map, inhabited by Animals and Beggars; in all the Land there is no other Relic of the Disciplines of Geography.

— Suarez Miranda, *Viajes devarones prudentes, Libro IV, Cap. XLV, Lerida, 1658*”

Borges’ redundant map in the story is an analogy for the futility of a model that incorporates very little abstraction. A model that is just as complex as the system itself is fairly useless. If such were the case, the modeller is then perfectly capable of understanding the system in all its complexity and would not have needed a model to do so. Such a rumination ties in nicely with the discussion on abstraction as a tool for model construction addressed in *The Role of Models in Science*. Just as one can decide to what detail to draw a map depending on its purpose, one can decide how much abstraction to include in a model. Any limitation of a model, therefore, should not be mistaken as a feature of the phenomenon. Instead, we understand that

1. It is possible to model a phenomenon at different levels of description and to different degrees of detail.
2. Models may address only some aspects of a system and not others.

Models for the emergence of various properties of solids, for example, can be constructed at the sub-atomic level or by considering a description of aggregate properties. The number and nature of variables involved in constructing a model may differ at each level. Progress in the creation of scientific knowledge happens at both levels of abstraction and in developing a way to relate the two.

Other writers have addressed the idea of redundant representations in fiction and elsewhere. Rosenblueth and Wiener themselves refer to an episode in Lewis Carroll’s *Sylvie and Bruno Concluded* [5] in which one character explains to another how in

A model that is just as complex as the original system is not useful for the purpose of explanation.



his country they had “made a map of the country, on the scale of a mile to the mile.” When another character inquires if they had used the map much, he is told that “. . . *the farmers objected: they said it would cover the whole country, and shut out the sunlight! So we now use the country itself, as its own map, and I assure you it does nearly as well*” [5]. Polish-American scholar Alfred Korzybski in 1931, makes a similar point about language that “*words are not the things they represent,*” by drawing an analogy (also with maps), that “*the map is not the territory*” [6].

A reference that does not involve maps, but cats, that also gets the same point across is in *The Role of Models in Science* itself, that “*the best material model for a cat is another, or preferably the same cat*” (p.320). However, a model identical to the original system is useless as a tool of human thought. Rosenblueth and Wiener, while concluding the essay, contend that the finiteness of the human mind necessarily means that science progresses through the use of ‘partial models’ (p.321), and thereby, we can contend, only through abstraction.

Generalisation as a Theme in *Funes the Memorious*

Along with abstraction, the act of generalisation is also important to model-making. Generalisation is the process of identifying a category from specific instances belonging to that category. To use an example from Rosenblueth and Wiener’s essay, in comparison with understanding the effect of a particular drug on the spike potential, understanding the effects of all the drugs belonging to a chemical group on the spike potential requires greater abstraction in the formulation of models and the identification of general principles. Modelling problems, or questions in science more generally, are typically approached by solving problems that are lower on the order of abstraction first and then seeking a more general understanding, which is typically also a few orders of abstraction higher. When we write down the equations of motion associated with a projectile and infer its parabolic trajectory, the generalisation is that the equations can describe not just that pro-

Generalisation is the process of identifying a category from specific instances belonging to that category.



jectile but also, to a reasonable degree of approximation, chucked pebbles and bowled balls as well as launched rockets. Ideal gas molecules in a box represent a range of possible realisations of large numbers of microscopic particles trapped in finite volumes.

In *Funes the Memorios* [2], Ireneo Funes is thrown off a horse and left paralysed. As a result of the accident, he is bestowed with the extraordinary ability to perceive and remember everything—“... when he came to, the present was almost intolerable in its richness and sharpness, as were his most distant and trivial memories.” The story is largely a narrator’s summary of an extraordinary conversation he has with the nineteen-year-old Funes over a single night, in which the range of Funes’ abilities and their consequences are made clear. “*Funes remembered not only every leaf of every tree of every wood, but also every one of the times he had perceived or imagined it*” (p.153). Funes’ perfect memory meant the inability to forget or ignore details to create general categories and concepts for objects and occurrences in the world around him.

He was, let us not forget, almost incapable of ideas of a general, Platonic sort. Not only was it difficult for him to comprehend that the generic symbol dog embraces so many unlike individuals of diverse size and form; it bothered him that the dog at three fourteen (seen from the side) should have the same name as the dog at three fifteen (seen from the front) (p.153).

The act of thinking requires abstraction and generalisation, both key features of models.

Several such examples are discussed in the story that emphasise Funes’ inability to partake in the process of abstraction and generalisation. “*I suspect, however, that he was not very capable of thought. To think is to forget differences, generalise, make abstractions.*” The reader contrasts their own experience of making sense of the world with Funes’, and this contrast forms a wonderful basis for a discussion about the act of constructing models in the production of scientific knowledge.



Discussion

Different disciplines consider the use of models in their explanations of phenomena to different degrees.

Different disciplines consider the use of models in their explanations of phenomena to different degrees. For example, when working with models of infectious disease spread or economic models, there seems to be an active awareness that what is being used is a *model*. At the same time, the use of models is second nature to those in other disciplines, such as physics, and there is a tendency to consider a model as not a specific representation of the real but as reality itself. It is of value to constantly remind oneself of this distinction and to recognise the formalisation of these processes as part of training and practice in the sciences. Towards this end, I suggest that classroom time be set aside for teachers and students to have a dialogue about models in science and that a linked reading of texts such as the ones suggested in this article is pedagogically valuable.

Fiction can introduce philosophical notions relevant to the sciences in contexts different from those a student would typically encounter in a science classroom.

Fiction can introduce philosophical notions relevant to the sciences in contexts different from those a student would typically encounter in a science classroom. Students in my classroom who have not engaged with the sciences or philosophy of science also seem comfortable with stories as a segue into the sciences. Stories that push the boundaries of creative imagination, particularly at the hands of a skilful writer like Borges, can open up many possibilities for an engaging discussion about ideas in the sciences. Texts dealing with the philosophy of science like *The Role of Models in Science* are not usually introduced in the science classroom either. However, their inclusion in lesson plans can help facilitate conversations about what science is and how science is done, irrespective of students' disciplinary leanings. I invite the reader to consider these and other such linked readings in their classroom.

Suggested Reading

- [1] A Rosenblueth and N Wiener, *The Role of Models in Science*, *Phil. Sci.*, Vol.12, pp.316–321, 1945.
- [2] J L Borges, *Funes the Memorious* (1942), Translated by J E Irby, *Labyrinths: Selected Stories & Other Writings*, pp.148-154, 1964.

- [3] J L Borges, *On Exactitude in Science* (1946), Translated by Andrew Hurley, *Collected Fictions*, pp.325, 1998.
- [4] R Frigg and S Hartmann, *Models in Science*, Ed. Edward N. Zalta, *The Stanford Encyclopedia of Philosophy*, 2020.
- [5] L Carroll, *Sylvie and Bruno Concluded*, Urbana, Illinois: Project Gutenberg (2015). Retrieved October 3, 2021, from www.gutenberg.org/ebooks/48795.
- [6] Korzybski, Alfred, *A non-Aristotelian system and its necessity for rigour in mathematics and physics*, Paper presented before the American Mathematical Society at the New Orleans, Louisiana, Meeting of the A.A.A.S. December 28, 1931.

Address for Correspondence
Sumithra Surendralal
Symbiosis School for Liberal
Arts,
Symbiosis International
(Deemed University),
Viman Nagar, Pune 411 014.
Email:
sumithra.surendralal@ssla.edu.in

