Our Friend the Atom

An Imagery Analysis of Disney's Science Book

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Abstract

In this article, we analyze images from the book “Our Friend the Atom,” written by the astrophysicist Heinz Haber in 1957 and developed in the Disney Science Department. In addition to analyzing the work, we investigate its relevance for science education. After the US attack on two Japanese cities with atomic bombs, there was a severance of opinions on nuclear technologies. On one side, it had an association with the destruction arising from the war. On the other, a narrative highlighted the advantages of using nuclear power for developments that would benefit humanity. Haber and Disney’s book aim to explain how such power works and supports its use for the good, despite the danger of destruction. Our goal is to contextualize the book’s content and its visual imagery and identify aspects to contribute to the science curriculum. We summarized the historical elements of the post-war period and Walt Disney’s entertainment approach and political stance. We discuss how it made a dialogue between a scientific concept and the general public through the book. For the matter of this article, we chose to examine one of the figures in the book, which represents through an illustration how chain reactions work to generate atomic power. For such, we followed a four-step methodology proposed by Silva and Neves *Em Aberto*, 31(103). (2018) to achieve an imagery analysis, giving us an understanding of the visual language contained in the book. It considers its visual choices, as shapes and colors, content, relations that involve the image, and interpretation of the picture as a whole by the reader. We came to understand the book’s importance as scientific literacy was achieved through its illustrations, text, and popularity.

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1 Introduction

The Walt Disney Studios communication is very particular, manipulating through visual language. The media with which Disney works tend to use the viewer's emotions and affection by involving them and creating empathy for the characters, ambiance, objects, etc. (Catmull & Wallace, 2014). Disney tries to reach people's feelings through animation techniques. It attempts to create emotions that are made with an authentic aesthetic and aims at the popular taste, creating an appeal that reaches distinct groups. Another factor that gave attention to Disney was the quality of realism in the imagery language. Disney has technical and artistic resources to bring the real world closer to fantasy as it deems necessary (Whitley, 2012).

"There is a close relationship between imagery and comprehension, as the understanding of sentences, paragraphs, and passages is increased when mental images are formed" (Cohen & Johnson, 2012, p. 927); based on this affirmation, in this research, we investigate the book "Our Friend the Atom." The primary study subject is imagery communication. In this article, we chose an image to analyze, according to Silva and Neves (2018) method. The selected image is a chain reaction allegory, explained with ping pong balls and mouse traps. This analogy is widely used to this day.

On the role of *analogy*, Jonãne (2015, p. 58) wrote:

Famous analogies in science frequently reveal an ability to make mental leaps. For example, the idea of envisaging heat as a fluid that can be contained in warm objects with the ability to flow from one object to another has been a powerful image throughout history and is still used today. James Clerk Maxwell developed the theory of electromagnetism by drawing physical analogies between fluid dynamics and electromagnetic phenomena. Albert Einstein, possibly the greatest metaphorical thinker ever, conducted thought experiments that helped to lead him towards his rebel view of light as particles rather than waves (...). As well as being an important cognitive mechanism in creative thinking, an analogical approach is a basis for problem-solving and forms a core component of everyday mental processing.

Therefore, our purpose with this article is to assess the relevance of the imagery aesthetic in this Disney's book to science education. Other researchers attempted to talk about "Our Friend the Atom," working both with the book and the animated movie. In each case, the authors researched the context in which the book was written or the animation was developed (Koehne & Heumann, 2018; Langer, 1995; Mechling & Mechling, 1995; Menéndez Navarro, 2015; Popova, 2013). These authors worked with Disney's representation of the atom and how the animation or book presented the metaphors and visual icons. As well as this approach, authors have scrutinized propaganda and intentions, trying to argue the beneficial or neutral image of the atom. This propaganda's central importance was to gain popular confidence and support for nuclear science (Mechling & Mechling, 1995; Menéndez Navarro, 2015). The narrative follows Disney's genre at its best, convincing the audience of the atomic power's positive aspects.

The Walt Disney Studio has learned to communicate ideas effectively, even using their characters to support political purposes, like war and public support for nuclear power investments. Disney can handle the dialectics of seeing and understanding that images and visual aids should not be viewed just as illustrations (Fischman, 2001). Jacobi and Schiele (1989) pointed out that science teaching has been using the media entertainment's visual language (such as theater, movies, television, and magazines) to the benefit of science popularization.

Through the book, the science behind atomic power reached laypeople. Even though it was not meant for formal learning, it played an essential role in spreading scientific literacy (Hofstein & Rosenfeld, 2008; Hurd, 1958). In addition to that, we found that analogies can be an efficient resource for science teaching (Gilbert, 2004; Stavy, 1991; Stuart, 2019), making the book an example of how art can assist science and education (McMullin, 1985).

In this article, we shall use methods presented by Silva and Neves (2018) to establish the connections between art and science, concepts in semiotics (Hoopes, 1991; Jappy, 2013; Short, 2007) accounting of signification, representation, reference, and meaning (Atkin, 2013). Besides that, emotional design (Norman, 2004), and principles of gestalt (Gomes Filho, 2009), referencing elements in form and shape in space, will support our explanations. Among 164 richly illustrated pages, we have chosen two images to exemplify an analysis of imagery. These images represent the book's aesthetics and show phenomena to the reader in a simple manner, as we will explore further.

The analogies and metaphors in the film are clear: fisherman/humankind; bottle/uranium; genius smoke/atomic mushroom; fission process/mousetraps. But in the Disney animation, the aims of the analogies and metaphors are not similar to those used frequently in classrooms. Aubusson and Fogwill (2006) wrote:

We assert that an analogy is successful not when it most accurately portrays ideas *per se* but when it promotes conversation, central to producing, evaluating and modifying the analogy, that helps students to clarify and to improve their scientific understanding. All models are flawed and hence all models break down (). There is always the danger that students may confuse the model with reality or the *claheunssroom* analogy with the scientific theory it is designed to emulate (Harrison & Treagust, 2000). A good analogy of itself does not portend good learning. Indeed there is a danger that efforts could be misplaced in seeking analogical perfection in the expectation that there is 'a holy grail to explain the phenomena' (Heywood, 2002, p.239). The break down of an analogy is not of itself a bad thing as it is, in part, by identifying, analysing and (perhaps) improving the analogy, that learning occurs.

The non-similarities are due to the use of fantasy like a fairy tale. The story begins with the following title: *Our Friend the Atom*. An anthropomorphism of an incredible "natural creature," as a person, as a friend. A mega-analogy. This introduces in a slightly way a powerful force of nature and the shadows of the destruction of Hiroshima and Nagasaki, in a friendly possibility to understand a hidden phenomenon.

Disney made history in the educational matter and science outreach. Van Riper (2011, p. 97) mentions that "programs' messages about science and technology were not new." Galileo Galilei himself was vocal and tried to democratize knowledge by writing in Italian instead of Latin, the scholars' language. Writing in Italian was frowned upon by his peers, as Italian was a vulgar language for plebeians. But Galileo explains: "I wrote in the vernacular because I must have everyone able to read it." Science literacy, despite dating Galileo's time, the 1950s, nowadays remains a pertinent discussion.

2 Disney's Education and Entertainment

Disney Studios was no stranger to working with the US government to support the country in terms of power. Even before the United States Navy requested film production, the day after the attack on Pearl Harbor, Walt Disney explored potential new revenues from

educational films and military training, with production contracts without a focus on entertainment, determined to profit from the war (Baxter, 2014). In June 1942, Disney Studios was formally declared a war plant, and the army was setting up its regular identification and control system (LESJAK, 2014). The studios produced not only military training films (Baxter, 2014, p. 04):

The studio also produced educational and propaganda shorts for the U.S. government, as well as creating morale-building posters and artwork for innumerable war-related organizations and publications. In addition, Walt set up a special department at the studio to provide colorful Disney insignia designs free of charge for the many Allied military units that requested them. (...) The studio also did its share of Hollywood troop entertainment, such as performing variety shows at area hospitals for wounded soldiers and hosting dances for locally stationed servicemen.

Disney also produced the film *Victory Through Air Power*, released in 1943, an animated version of the book of the same name by Alexander Seversky, a Russian aviation pioneer and influential defender of strategic airpower (Gabler, 2006). While most World War II films were created for training purposes, films like *Victory Through Air Power* were designed to attract government officials' attention and build public morals between the USA and the allies. After seeing the film, the notables who decided were Winston Churchill and Franklin D. Roosevelt, who said that Seversky and Disney knew what they were talking about (Gooch, 1995). Roosevelt recognized that cinema was an effective way of teaching, and Disney could provide Washington with high-quality information. The American people were coming together as Disney informed them of the situation without causing excessive chaos, as cartoons usually do. The animation was popular with soldiers and was superior to other documentaries and instructions written at the time (Gooch, 1995).

The film played a significant role in Disney Corporation because it was the beginning of educational films. Educational films have been, and still are, continuously produced and used by the military, schools, and factory instruction. The company has learned to communicate its ideas effectively and make films efficiently, introducing Disney characters to millions of people worldwide (i.e., Baxter, 2014). For the rest of the war, Disney characters effectively served as ambassadors for the world. In addition to *Victory Through Air Power*, Disney produced *Donald Gets Drafted*, *Education for Death*, *Der Fuehrer's Face*, and several training films for the military reusing animations of *Victory Through Air Power* in some of them (LIFE Magazine, 1942). A scene from the movie shows a fictional rocket bomb destroying a fortified German underwater pen. According to the anecdote, this directly inspired the British to develop a real rocket bomb to attack heavily protected targets with thick concrete. Due to its origin, such a weapon became known as the Disney bomb, having limited use before the end of the war (Spillman, 1997).

Walt Disney himself wrote in an article the intrinsic education versus entertainment relation. In his words:

The True-Life Adventures are made, and will continue to be made, primarily as entertainment. They are not designed specifically for conventional education. But in my definition, the overlap is implicit, To the extent that they are instructive, to that degree we must admit that they may also teach (DISNEY, 1954, p. 82).

The True-Life Adventures mentioned in Disney's quote is a series of documentaries he produced between 1948 and 1960. These documentaries were about nature and live animals, "The pictures in this series aimed to show the animals in their habitat doing what came natural to them" (Izard, 1967, p. 37). The ability to tell stories and the level

of excellence applied in Disney's works overlapped educational material. As a result, the information gained was successfully taught.

3 Historical Context

On August 6, 1945, the USA launched its atomic weapon at Hiroshima and again a few days later at Nagasaki, resulting in Japan's rapid surrender during the second World War. Some historians wrote that the atomic bombs were used primarily to intimidate the Soviet Union to gain the upper hand in Eastern Europe and to keep Moscow out of the war in the Far East (Alperovitz, 1995; Hasegawa, 2005). At that point, the public coexisted with the consciousness of atomic power while enjoying the exit from the Depression and the social prosperity of the post-war years (Martin, 2017). The population settled in post-war life with ease and comfort, living in growing suburban communities, taking over new consumer items the country offered, like flashy cars and television (Henriksen, 1997).

However, by September 1949, America's monopoly on atomic energy had ended after the Soviet Union's successful detonation of a nuclear weapon. Besides, the growing conflict in Korea had made the idea that the bomb could be used against the USA a real possibility (Martin, 2017).

In 1951, United States President Harry S. Truman created CONELRAD, Control of Electromagnetic Radiation, an emergency broadcast network designed to be used in the event of an attack (Scheibach, 2003). The intensity of such scores in American youth's lives felt most intense starting in 1954 when the federal government began its annual Operation Alert. It was an exercise in which Washington DC and fifty-four other cities across the country underwent an atomic attack simulation. Americans should run for cover when the Russian bombers approached (British Pathé, 1954).

Two narratives about atomic energy played in the media: nuclear weapons and images of destruction associated with them, like a growing mushroom cloud. However, another narrative emphasized a different phase of atomic research, in which scientists harnessed nuclear energy to benefit humanity rather than destroy it. "This is also atomic energy," continued the report, capturing scientists making strides in the fields of industry, agriculture, biology, and medicine, experimenting with radioactive materials (Warner Pathé, 1950).

Television was, in many ways, the dawn of modernism at Disney. The urgent need for programming allowed the company to launch Disneyland, the ABC network anthology that brought Walt Disney to television. The studios had to change to reflect everything that was happening at a rapid pace. New modernism was widespread in Southern California's arts and lifestyle, and the future surrounded the studio. The space race was underway, and the California Institute of Technology and NASA's Jet Propulsion Laboratory in Pasadena, CA, led the attack (Hahn, 2017). Modern design from the 1950s is based on earlier styles like the Bauhaus (i.e., Gombrich, 1995), which started in Germany, and the International Style, which grew out of the Bauhaus style in the USA, when many architects and designers migrated to America as a result of changes in Europe (Clayton, 2006). Inside the studios, the modernist style was introduced by director Ward Kimball, who produced the short film *Toot, Whistle, Plunk, and Boom* (Kimball & Nichols, 1953) (Fig. 1), and in 1954, the director Jack Kinney brought a more substantial commitment to this style, seen in the film *101 Dalmatians*, released in 1961 (Hahn, 2017).

The style brought by Kimball was then used in the studio's productions during the 1950s (Hahn, 2017), composing images that stood out in the post-war period in the USA (Clayton, 2006).

4 Our Friend the Atom

On January 23, 1957, Walt Disney Studios released an animated documentary for ABC Disneyland called "Our Friend the Atom." The television program came to the public as a narrative about the USA in a series organized around four themes within the park—Frontierland, Adventureland, Fantasyland, and Tomorrowland, presenting "Our Friend the Atom" as a story in Tomorrowland. Walt Disney saw this as an imperative project to bring science to the American public, thus complementing the film with a series of texts, including a book version of the script and a package of educational materials for US elementary and high schools (Mechling; Mechling, 1995, p. 436). A significant part of its content was "inherently abstract (like the laws of motion), many of their settings were beyond the reach of cameras (the inside of an atomic nucleus, the surface of the Moon), and most of the machines they described had yet to be built" (Van Riper, 2011, p. 87). They were successfully applied, preferring showing over telling, at a high level of sophistication.

The dust jacket placed on the book cover featured great minds who had toiled to today's utopia in science. Those names include Roentgen, seeing his hand in the first X-ray picture, Rutherford, bombarding the atom to find its nucleus, the Curies, searching for radioactive elements, and Einstein, working out the equivalence of mass and energy (Fig. 2). The book cover is made in a case binding, using a hardcover for an elegant look, and be more durable and robust, adding value to the piece. It has a bright red background, with a stylized human hand almost holding a representation of an atom, referencing the idea brought in the book of how humanity will choose to use that power (Fig. 3).

The book has a brief introduction by Walt Disney, in which he wrote "Fiction often has a strange way of becoming fact" (HABER, 1957, P. 10). It references the film 20,000 Leagues Under the Sea (1954), featuring "Nautilus," a submarine powered by a magical force. At that time, Disney reports that an authentic version of the American Navy submarine with the same name was the first in the world to be powered by atomic force.

It is proof of the useful power of the atom that will drive the machines of our atomic age. The atom is our future. It is a subject everyone wants to understand, and so we long had plans to tell the story of the atom. (...) Atomic science began as a positive, creative thought. It has created modern science with its many benefits for mankind. In this sense our book tries to make it clear to you that we can indeed look upon the atom as our friend. (HABER, 1957, p. 11)

Fig. 1 Scene from *Toot, Whistle, Plunk, and Boom* (1953), demonstrating the modernist style introduced at Disney studios in the 1950s. Source: (Kimball & Nichols, 1953)

Fig. 2 Dust jacket art on the “Our Friend the Atom” book. Source: Haber, 1957

“Our Friend the Atom” has 164 pages, some of which are richly illustrated. It is divided into 17 chapters, excluding Walt Disney’s foreword and prologue. It intends to explain to laypeople the basic concepts about atoms, creating a didactic transposition from the scholarly knowledge (Achiam, 2014). While some of the pages are somewhat technical, demonstrating radioactive decay curves of elements or the periodic table with only 101 elements

Fig. 3 “Our Friend the Atom” binding cover, Source: Haber, 1957

at the time, the story is then presented in a familiar Disney fashion as a fable: The Fisherman and the Genie. In Disney’s version of the story, the fisherman finds a lamp and is granted three wishes by a genie. It follows by explaining how, like the genie, the atom is mighty and even scary. Thus, it is up to humankind to understand its potential and choose to do what is good for the world: power, food and health, and peace, instead of war and destruction. “[...] the Fisherman had his means of making a friend of his enemy. Fortunately, science has its way of doing the same thing” (Haber, 1957, p. 134).

The result aims to reach an audience not necessarily involved in formal education, but for the curious and avid reader of new information. In this time, scientific literacy had a “boom” in the public interest, “Not only popular do media, such as newspapers, illustrated magazines, and exhibitions, but also novels, comic strips, and films, catered to this demand” (Lente, 2012, P. 2).

Walt Disney himself argues that, in his studios, they do not pretend to be scientists, but storytellers and, thus, to run the Disney Science Department, hired Dr. Heinz Haber, a German astrophysicist known nationally in the USA. Haber helped develop the program and was the author of the book “Our Friend the Atom.” The book reminds readers that this converging set of media include “a picture of the future life of man as it would be shaped by the fabulous achievements of science” (Van Riper, 2011, p. 224).

Within this article, we pursue a visual analysis of Disney’s book, evincing its role in understanding its contents. Our choice was to select a minute fraction of the book, richly

illustrated from beginning to end. The selection of Fig. 4 was made because of the important dichotomy it creates following a positive introduction for the atom. It is a vibrantly colored image portraying destruction caused by atomic power. Figure 7, which illustrates how a chain reaction works, was chosen to be analyzed for representing an abstract phenomenon through an analogy.

In disparity with the previous text, which shows how atomic power can be positive for humanity, there is the book's prologue. It comes with an illustration of a nuclear mushroom, in vibrant and contrasting yellow and red colors, causing the destruction of a city, referring to the bombing of Hiroshima and Nagasaki in the previous decade, as can be seen in Fig. 4. Such contrast shows the insight of Disney's work together with the USA government in transforming, in the public eye, something destructive into a possible prosperous force for human beings and favorable to political interests.

5 Science Literacy as a Path to Learning

Our friend the atom is an example of a book intended to the general public as an entertaining reading replete with imagery, meant to be as beautiful as it is didactic, to fulfill the enjoyment in the leisure time. At the time this book was written, there was an eagerness of interest in science and technology. It was mainly because of scientific revolutions of a practical nature, such as the evolution of medicine, which brought a quality of life, the initial development of electricity, telecommunications, and its popularization that brought alternative possibilities to the population (Matthews, 2011). There was also at this time a

Fig. 4 Atomic mushroom illustration in the book "Our Friend the Atom". Source: Haber, 1957, p. 12 e 13

fascination for futurism that grew among the public's eyes. The World's Fair was a demonstration of science and technology enchantment. It was a time of genuine interest in this matter. Hurd (1958) affirms that "Even the casual observer recognizes that science with its applications in technology has become the most characteristic feature of modern society." This book had come at a good time, along with the Disneyland television series.

This book was meant for informal education; the layperson could briefly understand what nuclear phenomena mean and how it applies to the everyday matters. On the same path, the television series was also at first advised for informal learning. Notwithstanding, these videos over-passed the living room and achieved the ground of the classroom. Hofstein and Rosenfeld (2008) state informal learning can and should overlap formal learning. Furthermore, they explain that drawing a line between formal and informal learning is overly simplistic; that is why the authors have taken a "hybrid approach."

Both book *Our Friend the Atom* (Haber, 1957) and videos have Disney's aesthetics communication. The edutainment spirit is vividly visible in the images and as an entire set of visual communication, didactics, and sound (in the videos). In visual communication and communication as a whole, analogies are widely used to reach what is typical for the spectator. In this case, the author (Haber, 1957) uses common everyday objects to explain the phenomena.

Among the different meanings, we adopted scientific as the focus on the competencies articulation related to scientific content and how the public approaches, understands, applies, and draws evidence-based conclusions in their daily life, enabling them to interpret their surroundings and assist it in conscious choices (OECD, 2000; Vizzotto & Pino, 2020). Beyond that, we assume scientific literacy as an engagement and desire to understand more about science and scientist works.

Analogies are a common resource for science teaching (J. K. Gilbert, 2004; S. W. Gilbert, 1991; Stavy, 1991; Stuart, 2019). Coll et al. (2005) point out that "Analogies are powerful tools of explanation" for abstract phenomena. Many authors as Coll et al. (2005) (for example, Fusti & Gilbert, 2000; S. W. Gilbert, 1991; Lucia & Lepsinger, 1999; Ornek, 2008; Shnitzer-Meirovich et al., 2018; Yeo & Gilbert, 2017) embrace models and mental modeling together with analogies. Treagust et al., (2002, p. 357) explain that "scientific models are often the only way to explain an abstract scientific theory and scientists' consensus models are taught as fact as a result of being the accepted model of a scientific theory, for example, the model of the atom." As a metaphor, model, or analogy, images are one in many possibilities, i.e., graphs, drawings, maps, diagrams, equations, schemes, pictures, animations, and concrete materials, such as tactile objects (Wang et al., 2015).

McMullin (1985) adopts the term "idealization" and clarifies "I shall take it to signify a deliberate simplifying of something complicated (a situation, a concept, etc.) to achieve at least at a partial understanding of that thing." In this case, with Haber's (1957) *Our Friend the Atom*, it is mostly used images as a modeling explanation. It is, on its own, a learning path.

6 Method

Silva and Neves (2018) propose an interdisciplinary image analysis method—in this case relating art and science—that covers the steps illustrated in Fig. 5. According to the authors, the first step is to analyze the form, which includes aspects such as colors, lines, sizes, and representational qualities of the image. The second step is a content analysis

of the image, that is, its proposition and meaning. The third step is an analysis of relations that involve the image, meaning who the author and the reader are, the purpose of the image, and the relationship between author, reader, and circumstances that conceived the image. Finally, the fourth step is the interpretive analysis of the reader, in which one seeks to understand the picture as a whole, which is now a representation that manifests itself. From this, the analysis of images in the book “Our Friend the Atom” can occur to investigate the subject that an image portrays, and its content and concept within a given context (Silva & Neves, 2018, p. 30).

We are also referring to another three concepts for this analysis: semiotics, gestalt, and emotional design. As for the semiotics—or the science of signs—the following image (Fig. 6) represents the connections between the user (interpretant) and its relations with representation and signs. The representations are how one comprehends the world and makes its interpretation by the means of signs. We can understand representations as an abstract concept as denotative, as a formal explanation of information; we may say that it is the dictionary definition; and the connotative as the interpretants reference through the object and its synthetical proposition in which signs are predicated or subjected, meaning that there is a personal or cultural view in interpretation it embodies (Hoopes, 1991; Jappy, 2013; Short, 2007).

According to Peirce, signs can be anything as long as someone gives it meaning other than themselves. We subdivide signs into two parts to understand them: signifier, the physical form of a sign such as the written word or the image that creates the communication, and signified, the abstract concept the signifier represents (see Short, 2007). So that it is possible to have a reading, we categorize a signifier into three types of signs: an icon, the visual representation of objects’ resemblance it denotes; a Symbol does

1st Step Shape Analysis	Formalist perspective Reference: Dondis	Analyze the colors, lines, dimensions, and other expression qualities of the image
2nd Step Content Analysis	Warburgian perspective Reference: Panofsky	Analyze the theme and meaning of the image
3rd Step Analysis of the relations surrounding the image: author x context x reader	Perceptualist or semiological perspective Reference: Gombrich	Analyze who is the author, the reader, for what purpose the image was produced, what is the relationship between the author, reader, and the context in which the image was produced
4th Step Interpretative analysis of the reader	Phenomenological perspective Reference: Merleau-ponty	Perform an interpretive analysis, seeking to understand the image as a representation that goes beyond what it represents, that has its own expression

Fig. 5 Steps proposed to analyze for interdisciplinary images, translated. Source: (Silva & Neves, 2018)

Fig. 6 Fundamentals of semiotics

not have the physical resemblance with the object, but loosely denotes the object by a concept pre-established in a given rule, meaning that the interpretant is needed to give it meaning in association to an idea; and indexes can be explained as the dynamic relationship to an object casual result. It cannot be dissociated from an existential relationship between the signifier and the physical presence of the signified.

The theory of signs is richly studied in linguistics and by extension applied in visual communication. Despite the lack of grammatical formalism, visual language has rhetoric, narrative, the effectiveness of language, and semantics (Kress & Leeuwen, 2006). That is, semiotics allows an understanding in-depth of the interpretant-representation-sign triad, explaining it as a language that communicates. Blair (2012, p. 205) argument that “A single visual image can probably be more powerful than a single verbal assertion.”

Barthes (1968) reiterates the fact that variants that are not significant on the plane of denotation “can become significant the plane of connotation, and from being combinative variants, they refer now to two different signified” (Barthes, 1968, p. 85).

Gestalt, integration of parts as opposed to the sum of the “whole,” tells us that the human perception follows rules, such as unity, segregation, unification, closure, continuity, proximity, similarity, and pregnancy of form, all of which give the scientific basis

to this visual reading system (Gomes Filho, 2009). This means that every form found in the analyzed images has a purpose and intention in the way they were disposed of.

As an approach to emotional design, Norman (2004) argues that the emotion a design infers, in some ways, may play a more critical role in investing the public than its originally proposed value. The author defines three different aspects of a design that can emotionally invest someone: visceral, behavioral, and reflective. The visceral design concerns the appearances. Behavioral design concerns pleasure and effectiveness. The reflective design concerns rationalization and intellectualization of a product. When it comes to Disney's *Our Friend the Atom* book, the public is bound to the Disney way of presenting things visually. Viscerally, one can be dazzled by Disney's aesthetics. Behaviorally, having such a book in hands can be a pleasure, for the edition is a hardcover, thick-paged, well-edited book, with clear naming and division of chapters, describing each paragraph cautiously and clearly for the general public to be able to understand those topics about the Atom. Reflectively, it adds up information about a topic that was in the spotlight at the time, so its intellectual value to an owner of such a book can be very high.

7 Analysis of Imagery

The book "*Our Friend the Atom*" adopted the studio's modernist aesthetic during the post-war period and widespread in the USA throughout the 1950s and 1960s. On page 66 of the book, Heinz Haber discusses how advanced mathematics was in the nineteenth century, presenting the recognition of the motion of atoms. He proceeds to the extremely violent motion of atoms and molecules when exposed to heat, exemplifying such a process with one example: putting an ice cube in a jar and placing both over a fire. Alongside the written explanation of the phenomenon, there are two illustrations of it (Fig. 7).

On the first selected illustration, there is the representation of a teapot with a cube of ice in it. The teapot is placed on top of a lit candle. Based on semiotics, the denotation of those objects is simple to read, except for the cube of ice, which does not resemble an actual one, but the molecules it contains and the state they are in at the given moment. The molecules are represented by circles. So, it needs a connotation, another reference to be interpreted. Following the rules of gestalt, the image has unity, for it represents a scene and all it intends to show; unification and closure in the way the molecules of ice are placed (showing they're still); similarity in a way the representations of the teapot and the lit candle closely resemble real ones, being easily identified, being an icon; and pregnancy of form, considering how the representations are simplified versions of an actual teapot, an actual lit candle, and actual water molecules. On the second illustration, it is important to notice the focus given to the faster movement of the water molecules, especially as they get faster with the heat, becoming steam "dashing around with their greatest force—enough force to push the lid off the jar" (Haber, 1957, p. 67). The molecules are now chaotic, and its connotation implies movement, especially when placed together with the steam. The two illustrations show two different states of water molecules, how they behave before and after an exterior force is applied to them. Gestalt and Peirce's theory of semiotics are important to understand what the illustrated signs are and what they represent. Disney's modernist aesthetics refers to its utopian views at the time, implying positiveness for the future, with the help of technology and science, which is being represented in those illustrations.

The teapot and candle, being easily recognizable, create a positive relationship of the reader with the image, for we can find them in most people's homes and resemble coziness.

Fig. 7 Illustration of an ice cube boiling inside a jar placed on a fire. Source: Haber, 1957 p.67

The tilted lid was illustrated in a cartoonish way, and because cartoons, at the time, were mostly watched for entertainment, the public could emotionally relate to it on a visceral level.

As shown on the TV series (Luske, 1957), Haber's lecture on nuclear chain reactions was shown in a short film in Technicolor, as the scientist tosses a ping pong ball on a tabletop demonstration with cocked mousetraps representing unstable atomic nuclei (of uranium 235, for example). Other ping pong balls, set atop them (two on each mousetrap), representing the neutrons, set free when they split. "A single ping pong ball, dropped onto the table from above, triggered a spectacular flurry of activity and ends the concept of chain reactions instantly memorable" (Van Riper, 2011, p. 92), as shown in Fig. 8.

This analogy is so powerful to represent the chain reaction it keeps popping out into many others contexts, such as in the Ohio Department of Health campaign to beget awareness about social distancing to avoid risks to contract the SARS-CoV-2 (Fig. 9). The idea is not similar, but analogous, in using crowds of people to show the danger of contamination (a set of several cocked mousetraps), and, after, the effect of mousetraps well separated as an analogy of "social distancing." On the book, this illustration will appear on page 131, an illustration graphically exemplifies the chain reaction—derived from atomic fission explained in the book's text—like mousetrap powered by a ping pong ball, a motionless representation of the mousetrap experiment shown on tv (Fig. 10).

Reading the image according to the method of Silva and Neves (2018), it is possible to observe, in the first step (Shape analysis), that the pastel yellow color of the background contrasts with the green without defined volume (tones may vary in digital format). The mousetraps, brown, have no outlines; there is no perspective. They base on the stylization of the object and, as well as the ping pong balls (in pastel beige), they are geometrized (Caduro, 2008).

The elements are asymmetrical, placed in the image without an order to follow. In between, there are pastel straight and curved dashed red lines. The traps set according to the golden ratio (it was not necessarily the illustrator's intention to place them like that, but the ratio is a way to give eyes direction in reading images and we will use it as a starting

Fig. 8 Chain reaction as represented in the “Our Friend the Atom” TV series. Source: Luske, 1957

Fig. 9 The Ohio Department of Health has a powerful message for the public: Social distancing works. Source: (Horton & Bernstein, 2020)

point for the analysis); all are facing the observer but in different positions (Fig. 13). The mousetraps are icons, for they resemble closely the actual object in their representation, although it is simple. Therefore, there is the gestalt principle similarity. Continuity can be seen in the object's repetition. Segregation can be seen in the display of the mousetraps, and unification in the group of elements. The ping pong balls can also be read under the perspective of gestalt. They are all equally represented (unification) as light-colored circles (pregnancy of form), briefly showing any three-dimensional shadows in a few of them. They are segregated when it comes to their position in the illustration. On the left part of the illustration, one might think that there is unity, but on the right side, it is possible to see portions of the balls missing, implying that they spread even further, out of the picture. The pregnancy in the image is chaotic, due to the presence of various elements in different perspectives and positions.

In semiotics, the interpretant can understand the signs by the means of representation, under both connotative and denotative definitions. In a view of denotation, one can clearly understand that there are mousetraps and circumferences representing balls, but without the connotative support, the reader would not be able to understand the analogy, for there is a nuclear fission phenomenon to relate it to.

The ping pong balls follow the same distribution type, even when, overall, the appearance is chaotic and disordered (Figs. 11, 12). Notwithstanding the tumultuous arrangement,

Fig. 10 Chain reaction illustration. Source: Haber, 1957 p. 131

Fig. 11 Distribution of the rat traps in the image. Source: Haber, 1957; adapted by the authors

it causes “the rationally based sensation of beauty, such design had to convey the idea of a universal order in nature” (Galili, 2013, p. 1915).

In the second step—content analysis, as previously reported—we have a representation of a chain reaction as mousetraps driven by ping pong balls. The mousetraps, similarly represented to actual ones (icons), represent uranium atoms (as both contain trapped energy), and the balls represent neutrons (Haber, 1957). Some mousetraps represent the before and others the after-action, implying that one leads to triggering the other. The red lines appear throughout the entire image, at random, not always showing a starting or ending point (even, theoretically, starting from the mousetrap), giving them a chaotic direction. They are dashed to indicate movement, where the ping pong balls are supposed to have passed (Fig. 13).

In the third step, analysis of the relations that involve the image, we must verify who is the author of the picture. However, the book does not specify which of the fifteen Walt Disney Productions artists involved in the project, under Paul Hartley’s art direction, made the image in question. The intended reader for the Disney studios was the American general public, who would have access to prepared information about nuclear power both through the book and on a television series on Sundays. According to Halden (1986), during the Cold War, the American government tried to reposition nuclear technology as a benevolent force through atomic energy. The work done on “Our Friend the Atom” by Disney attempted to allay fears about nuclear effects and educate the public about technology’s

Fig. 12 Distribution of ping pong balls in the image. Source: Haber, 1957; adapted by the authors

positivity as the nuclear power industry began to rise more dominantly (Halden, 1986). Evans (2017) puts the job of the Walt Disney Company, which had a popular appreciation for the American government, as “a new, relevant, and adventurous advertisement.” It is important to remember that “Our Friend the Atom” was released in the Tomorrowland series, placed as a possible futuristic resource to be used in rocket propulsion, medical treatments, livestock, and agriculture, helping feed a “growing population” (Huebner, 2009).

Finally, the proposed fourth step seeks to interpret the image as a whole. In the case of said book with scientific information, explaining to the public a scientific event, with purposes involving government propaganda for this event, the illustration is opposed to order, showing controlled chaos, and fulfills its informative role. Machado and Braga (2016) explain that such representation is an “attempt to understand the internal mechanism of a system or event. This mechanism is hypothetical, and it is invented using unobservable and abstract concepts” (Machado & Braga, 2016, p. 830). Based on concepts created in post-war modern art movements, such as abstract expressionism and the coloring of color fields (The Art Story Contributors, 2011), Disney Studios produced a work that represented the modernism of the time in an image showing behavior and how a nuclear reaction occurs. For instance, Disney’s approach to popularizing atomic power science differs and stands out from the ordinary school book. Science textbooks produced for formal education tend to display technologic and scientific knowledge as more specialized and divergent from the daily knowledge compared to books of scientific curiosities for laypeople (i.e., Bungum, 1970; DIMOPOULOS Et al., 2003), like *Our Friend the Atom*.

8 Implications in Science Teaching and Science Literacy

The *Disneyization* of science present in the worldview of *Our friend the atom* claims to the opening of a new world, using a great scientist and science communicator, Haber, like Von Braun, occupied in a new world’s race against the soviet: spatial and nuclear races. But the film, using aspects of the history of science, starts with Democritus until the atomic age of the last years of the nineteenth century and the beginning of the four decades of twentieth. The story of atomic science present in the film is close to a conception of the *night science*, as described by Jacob (1998, p. 126):

Fig. 13 Distribution of red lines in the image. Source: Haber, 1957; adapted by the authors

And yet when you look more closely at “what scientists do,” you might be surprised to find that research actually comprises both the so-called day science and night science. Day science calls into play arguments that mesh like gears, results that have the force of certainty. Its formal arrangement is as admirable as that of a painting by da Vinci or a Bach fugue. You can walk about in it as in a French garden. Conscious of its progress, proud of its past, sure of its future, day science advances in light and glory. By contrast, night science wanders blind. It hesitates, stumbles, recoils, sweats, wakes with a start. Doubting everything, it is forever trying to find itself, question itself, pull itself back together. Night science is a sort of workshop of the possible where what will become the building material of science is worked out. Where hypotheses remain in the form of vague presentiments and woolly impressions. Where phenomena are still no more than solitary events with no link between them. Where the design of experiments has barely taken shape. Where thought makes its way along meandering paths and twisting lanes, most often leading nowhere. At the mercy of chance, the mind thrashes around in a labyrinth, deluged with signals, in quest of a sign, a nod, an unexpected connection. It circles like a prisoner in his cell, looking for a way out, a glimmer. It vacillates endlessly between hope and disappointment, between exaltation and melancholy. There is no way to predict whether night science will ever become day science; whether the prisoner will emerge from the darkness.

The night science is the magic that allowed atomic ideas to put, after the ashes of devastated cities Hiroshima and Nagasaki, in the daily experience of normal science, like in the Kuhnian epistemology.

Especially at the time *Our Friend the Atom* was released, the Disney label was synonymous with the American Dream. A culture is a sharing of ways of thinking, as well as symbols and beliefs, and the Disney Culture promotes:

a distinctive way of viewing the world. It provides immersion in childlike fantasy and simulation (Disney Magic), facilitated by media technology, and control (the Disney way) and mass consumption (Disney dollars). Disney Culture rests on the assimilation of other stories and ideas (the world according to Disney) that are reduced to impart a range of traditional and progressive values. [...] Put Simply, Disney Culture is our culture reshaped by Walt Disney: it is a Mickey Mouse take on the World (Wills, 2017).

Wills (2017) defends that the Disney culture became expansive and diffusive, being seen even in schools and family life around the world. The *Disneyization* of society is represented whereby “Disney both influences and exemplifies new trends in consumer life.”

Disney is tied to American iconography, childhood experience, popular cinema, suburban family values, social conservatism, and also change. The rise of Disney reflects the rise of both visual culture and consumer culture in the twentieth century. Disney Culture is tied to popular forms of patriotism and progressiveness. For some people, Disney is the essence of the American way. The Disney critic Stephen Fjellman labels Walt Disney World in Florida “the most ideologically important piece of land in the United States (WILLS, 2017).

Disney connected with childhood ideas, growth of consumer culture, and a national propensity for nostalgia and a utopian future. Disney provided an escape in periods of struggle, such as the World War, the Great Depression, and the Cold War. Emotionally, it was deeply connected to the American culture of the time. The Disney product was sold because of a farsighted and astute marketing, technical excellence, and emotional impact. Our Friend the Atom, therefore, is another way Disney influences the public to its political views: supporting the atomic force, by teaching, in their Magical way, how it works.

Furthermore, it is noticeable how the mousetrap experiment illustration (Fig. 10) references the boiling water experiment previously presented (Fig. 7). The free, chaotic movement of molecules causing others to move is shown analogously. That is, not only the style remained the same, but mainly the representations used the same visual codes: molecules as circles and movement as lines going many directions in a given space. The written explanation about how the actions begin in Fig. 10 is similar to the one provided for Fig. 7: “When the fast molecules in the flame bounce against the molecules of the glass, the latter too, start moving faster. In turn, the glass molecules bounce against the ice molecules and start them vibrating faster, too. It’s like a pool game with the balls bouncing against each other” (Haber, 1957, p. 67). The representational approach (see, Machado & Braga, 2016) the authors used to explain boiling water applies a physics phenomenon to a common daily experience. That makes it more relatable for the average public due to the presence of continuity (see, Dewey, 2005; Girod et al., 2003; Jakobson & Wickman, 2015; Toscano & Quay, 2020). Even the representation of the jar’s movement makes the illustration ludic, not static, and more entertaining. With that idea clear, it becomes easier for one to understand what is explained later on the atomic chain reaction (Fig. 8).

Initially, this book and the videos were meant to spot the leisure time for science literacy-orientated learning. Disney (1954, p. 82) argues that “The True-Life Adventures are made, and will continue to be made, primarily as entertainment. They are not designed specifically for conventional education.” Nevertheless, these videos surpassed serving the purpose of amusement to the classroom floor, becoming a didactical tool (edutainment, as cited before). It is because of the kind of communication it presents, dialoguing with the public through the viewpoint of edutainment.

The videos and the book fit Disney’s fashion. It is their characteristic to present ideas in an enjoyable, clear, and understandable way. Disney has this crate approach, even when it comes to such a controversial subject, making nuclear energy a friendly topic even though it was used as a weapon. Langer (1995, p. 86) argues that “all these things were turned, by Disney magic and with Disney color, to sheer fun, as though the real purpose of technological achievement, after all, was human happiness.” Baxter (2014) and Popova (2013) also discuss this matter, piecing together Disney to the war.

Still, this friendly communication is widely used and encouraged in classrooms. Henry Wallon, Jhon Dewey, Maria Montessori, and many other theorists are vocal about this kind of attitude towards pupils (Blair, 2012; Cunha, 2016; Krogh, 1982; La Taille et al., 1992). Mahoney and Almeida (2005, p. 19) state that affectivity “Refers to the ability, the willingness of the human being to be affected by the external/internal world by sensations linked to pleasant or unpleasant tones.” Closely related is emotion; fear, joy, anger, jealousy, and sadness, and which, for these authors, are the answer to a stimulus; run, stay, attack, relax, and so on. These experiences can change education, contributing to or hindering learning. Dewey (2005) touches on emotion and affectivity matter and goes further; he handles art, experience, and motivation. Girod and Wong (2000) points out that Dewey says that “The task of school is to provide students with transformative experiences: experiences that are valuable in themselves and in their potential to lead to other worthwhile experiences.”

The arts, above all, teach us something about what it means to undergo an experience. “Successful encounters with art objects and performances offer a set of standards by which to judge ordinary experiences.” Therefore, Dewey’s theory meets the Disney principle. Walt Disney (1954, p. 83) explains that the videos were meant to be “informative as well as entertainment values.” To create this “reaction,” Disney studios would build an experience, as well as the book and its images.

Images are a path to stimuli learning, as it is a type of metaphor, which helps the understanding. Ryan (1993) argues that:

The old saying that a picture is worth a thousand words may or may not be true. What is true, however, is that one appropriate picture can be a catalyst giving rise to the production of thousands of words and a multitude of creative and analytical thoughts.

Imagery and aesthetics enable an enriching experience. It is easily remembered, makes learning meaningful, encourages visual literacy, and shapes engagement (Pugh & Girod, 2007). Berry et al., (2008, p. 428) argue the importance of visual experience, pointing that “images have in terms of memory and long-term learning.” As their text follows, they explain that it is common to relate teaching and learning through images with textbooks, although what comes to mind are bland, neutral pictures with little emotion. It is not *Our Friend the Atom*’s case (Haber, 1957). The rich, exciting, colorful book creates a unique dialectic and readability, composing images with meaning for every detail composing the art and aesthetic; consequently, the book creates an enjoyable experience for the reader. As an example, in Fig. 10, all the composition is made to attract the reader. All other images presented in this paper have a reason for why color, form, object, shape, context, empty space, and movement (Garcia, 2010). The narrative is intentional.

9 Concluding Remarks

Visual imagery is one of Disney’s major assets, and Walt Disney used that ability to tell stories. Some served as educational material, and even though “*Our Friend the Atom*” had a political purpose, it was effective in the educational one.

The Disney Studios are historically known for supporting the US government. However, the visual language they used in “*Our Friend the Atom*” is not discussed as to their other materials concerning the Second World War. We understood the selected image in a specific context, its role in such context, and analyzed its visual information.

Following the method proposed by Silva and Neves (2018), it was possible to understand each information contained in the image, giving us a better notion of why the visual information in the book is as it is.

As Cohen and Johnson (2012, p. 928) apprise, “Imagery plays a major role in facilitating learning” and “it is important to incorporate images when instructing students on new meanings and concepts.” Being guided by this and the images, we point to the relevance in science using images as an educational tool. Many authors are unison in the quality of images as an enhancement to learning science (Cohen & Johnson, 2012; Fischman, 2001; Jacobi & Schiele, 1989). As initially meant to stay on the entertaining side, the videos surpassed barriers and arrived at school to be a teaching assistant. The book, however, maintained its position as informal learning auxiliary to scientific literacy. This qualitative method we used was a path to show the importance of imagery analysis and its implications. Images must be created to enable an experience, and as Berry et al. (2008). But our research with emotional images suggests that “neutral” images may not just be skipped by students, they may also be a distraction to learn. This shows the relevance in reading images and analyzing composition and context.

Our Friend the Atom was able to make enjoyable a complex, controversial, political, and frightening subject. Disney’s aesthetic and edutainment actions were crucial to developing this work of art and science.

The power of the story and images of Our Friend the Atom is the message to the world (although it is based in the North American establishment and in its way of life). The images are cross-temporal in the sense that the impact of the analogy of the mouse-trap to explain the atomic fission was used in recent publicity to protect people against the SARS-CoV-2 (coronavirus) as we mentioned in this paper.

Recently, it was in exhibition the film “Radioactive” (Satrapi, 2019), counting the history of Mme. Curie’s discoveries. The film is enthralling for there is a temporal division in three future planes, after the scientific works of Mme. Curie: radiotherapy, nuclear tests, and Chernobyl. Such aspects are similar to the book Our Friend the Atom: peace (or the lack of it—with the use of the atomic bombs), health (because of radiotherapy), and the risk of the control over the fission process to obtain energy. Separated by 60 years, the two works are linked to the archetype represented in the *Disneyzation* process of atomic power.

In this article, we find that we fulfilled our objectives in understanding the selected imagery and its context. We propose a continuation of this study concerning the book, analyzing other images it contains and the text that accompanies them. It should give us an even more extensive range of information about its educational purpose and visual representation and the aspects not well explored of nightly and daily science, as proposed by Jacob (1998).

As Blair (2012) stated, images can express more meaning than written/spoken words, so they can be an aid to the teaching and learning experience, giving more significance, affecting the public in different ways. By the means of emotions, it can help students to engage more with the subject, making it a transformative experience, in Dewey’s (2005) words. Extending the concept of formal education to an informal intended book, we can say the importance of a leisure reading is the emotional engagement of the lay public. Disney was a master of visual language, appealing to the public and even making of it a political stance. Therefore, we can conclude that being positively emotionally engaged in a book about science can be a way in which people learn and awaken the desire to seek more about scientific phenomena.

Norman (2004) states that a negative affect makes the public feel more anxious and uncomfortable, although it makes the reader more attentive and focused. On the other hand, a “positive affect arouses curiosity and engages creativity, and makes the brain into an effective learning organism” (p. 26), but one is far less focused and far more likely to be receptive to interruptions. Therefore, it is necessary to have a balance between the positive and negative effects. It is important that the reader feel happy and in a pleasant mood, but that there is enough discomfort that they focus, to ensure that all the information is attained. Both analyzed images, in this article’s case, contain chaos and calmness, and the aesthetics Disney adopted were well versed in a way it becomes useful for science literacy.

Although the generalization this text may imply, there are limitations in this research since we analyzed only 2 images from this fully illustrated book with 164 pages. Future studies could employ an analysis of other illustrations and comparisons with textbooks made for formal educations. Regardless of these limitations, the present research discusses theoretical implications in imagetic communications for the lay public, grounding theoretical base in semiotics, gestalt, Norman’s (2004) emotion design along with Silva and Neves (2018) interdisciplinary image analysis method. Therefore, this research could be a starting point to others’ analyses regarding the relationship between scientific literacy and science textbooks.

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Declarations

Conflict of Interest The authors declare that they have no conflict of interest.

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