EDUCAÇÃO EM FOCO
PROGRAMA DE PÓS-GRADUAÇÃO EM EDUCAÇÃO | UNIVERSIDADE DO ESTADO DE MINAS GERAIS

Signos e significações em livros didáticos de ciências: diagramas em foco[1]

Maria Ogécia DRIGO[2]
Luciana Coutinho Pagliarini de SOUZA[3]
Maria Alzira de Almeida PIMENTA[4]

Resumo
O tema deste artigo está na interface comunicação/educação, na qual disciplinas escolares são vistas como linguagens, ou sistemas de signos, o processo de aprendizagem como um processo de signos em ação e o aprendiz como intérprete de signos. Assim, com o objetivo de explicitar o potencial do diagrama para colocar a cognição em movimento, apresentamos aspectos gerais da amostra estratificada e constituída por 30% das 68 coleções recomendados pelo Programa Nacional do Livro e de Material Didático - PNLD 2020 – Ensino Fundamental II – que compõe o *corpus* da pesquisa, e o recorte realizado para o âmbito deste artigo; em seguida, definições e classificações de signos que constam na gramática especulativa, parte da semiótica ou lógica peirceana; o conceito de diagrama e justificativas, de certo modo, porque as tabelas, Table s, Graphs, mapas, infoGraphs e mapas conceituais podem ser vistos como diagramas e, por fim, analisamos tais diagramas.

Palavras-chave: Comunicação. Educação. Linguagem. Representação visual. Semiótica peirceana.

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[2] PhD in Communication and Semiotics from PUC/SP and Postdoctoral Fellow in Communication Sciences from the School of Communications and Arts at USP/SP. Professor in the Graduate Program in Communication and Culture and the Graduate Program in Education at the University of Sorocaba (Uniso). ORCID: https://orcid.org/0000-0002-5123-0610. E-mail:maria.ogecia@gmail.com.
[3] PhD in Communication and Semiotics from PUC/SP and completed a postdoctoral fellowship at the University of Kassel, Kassel, Germany. Professor in the Graduate Program in Communication and Culture at the University of Sorocaba (Uniso). ORCID: https://orcid.org/0000-0002-1995-8791. E-mail:luciana.souza@prof.uniso.br.
[4] PhD in Education from the State University of Campinas. Professor in the Graduate Program in Education and the Graduate Program in Communication and Culture at the University of Sorocaba (Uniso). ORCID: https:/orcid.org/0000-0002-5775-5856. E-mail:alzira.pimenta@gmail.com.

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Signs and meanings in science textbooks: diagrams in the spotlight

Maria Ogécia DRIGO
Luciana Coutinho Pagliarini de SOUZA
Maria Alzira de Almeida PIMENTA

Abstract
The theme of this article is in communication/education interface, where school subjects are seen as languages, or systems of signs, the learning process as the action of signs and the learner as interpreter of signs. Thus, with the aim of explaining the potential of the diagram to put cognition in motion, we present general aspects of the stratified sample, constituted by 30% of the 68 collections recommended by the National Book and Teaching Material Program - PNLD 2020 – Elementary Education II – which makes up the research *corpus*, and the selection made for the scope of this article; then, definitions and classifications of signs that make up the speculative grammar, part of Peircean semiotics or logic; the concept of diagram and justifications, in a way, since tables, charts, graphs, maps, infographics and concept maps can be seen as diagrams and we analyze such diagrams.

Keywords: Communication. Education. Language. Visual representation. Peircean semiotics.

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Signos y significados en los libros didácticos de Ciencias: los diagramas en el punto de mira

Maria Ogécia DRIGO
Luciana Coutinho Pagliarini de SOUZA
Maria Alzira de Almeida PIMENTA

Resumen
El tema de este artículo es la interfaz comunicación/educación, en la cual las disciplinas escolares son vistas como lenguajes, el proceso de aprendizaje como signos en acción y el aprendiz como intérprete de signos. Con el objetivo de explicar el potencial del diagrama para poner en movimiento la cognición, presentamos aspectos generales de la muestra estratificada con 30% de las 68 colecciones recomendadas por el Programa Nacional de Libros de Texto y Material Didáctico - PNLD 2020 - Enseñanza Fundamental II - que componen el corpus de la investigación, y la selección realizada para este artículo. En seguida, presentamos definiciones y clasificaciones de signos encontradas en la gramática especulativa, parte de la semiótica o lógica peirceana; el concepto de diagrama y justificaciones, en cierto modo, de por qué tablas, cuadros, Graphs, mapas, infografías y mapas conceptuales pueden ser vistos como diagramas y, por último, analizamos estos diagramas.

Palabras clave: Comunicación. Educación. Lenguaje. Representación visual. Semiótica peirceana.

Introduction

This article aims to highlight the potential of diagrams, present in textbooks, to trigger cognition, here understood as semiosis or the action of signs. To achieve this objective, we present aspects of speculative grammar, a branch of Peircean semiotics or logic, which allows us to approach school subjects as languages also composed of signs other than words, such as formulas, graphs, and others. This perspective prompts new ways of perceiving, observing, and thinking.

Regarding textbooks, it is worth noting that they often include images or visual representations, such as reproductions of photographs and other media images, drawings, maps, tables, charts, and more. This makes textbooks, in general, present school subjects using a verbo-visual language. Concerning images, it is essential to emphasize that, although intellectual thought has consistently maintained a “fear of the world of images, while the 'city of letters' continually seeks to control the image, confining it in a Manichean manner to the realm of art or the world of deceptive appearances and magical remnants” (Martin-Barbero, 2014, p. 104), images persist, return with force, penetrate educational environments, and establish themselves. They introduce a new cognitive status that unsettles traditional ways of thinking about knowledge and, we add, lead us to reconsider our conceptions of cognition and how thinking itself occurs. Thus, to understand the issues arising from these transformations, it is necessary to bring education closer to Peircean semiotics, the latter being understood here as the general science of signs. Among visual representations, diagrams stand out as a modality addressed in this article.

Subsequently, amidst definitions and classifications of signs found in speculative grammar, we address the concept of diagrams and explain why tables, charts, graphs, maps, infographics, and conceptual maps can be considered diagrams. Finally, we identify the potential of these diagrams to stimulate cognition, particularly those we selected from science textbooks belonging to collections indicated by the 2020 edition of the National Textbook and Teaching Material Program (PNLD). General data on the sample, specific data from science collections, and the diagrams selected for analysis are presented.

Methodological Contributions

The sample that constitutes the research corpus is stratified and comprises 30% of the 68 collections listed in the 2020 PNLD guide for Lower Secondary Education, corresponding to 23 collections of subjects from this phase of basic education (Table 1).

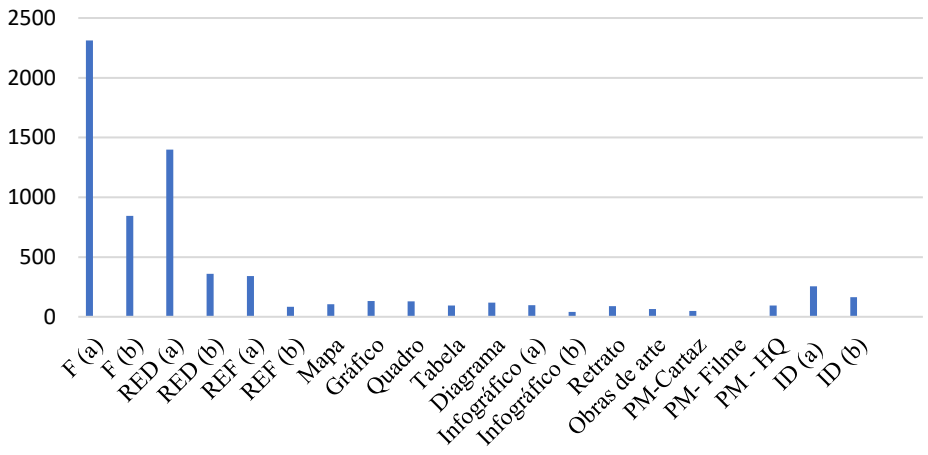
Table 1: Number of Collections per Subject for the Stratified Sample

Subject	Number of Collections	Number of Collections in the Sample
Portuguese	6	2
Science	12	4
Mathematics	11	4
English	9	3
Geography	12	4
History	11	4
Arts	7	2
Total	68	23

Source: Prepared by the Authors.

Para este artigo vamos nos limitar ao estudo das coleções de Ciências. Contabilizamos as representações visuais presentes nessas coleções e os resultados constam no Graph 1.

Graph 1 - Number of Visual Representations, by Modality, in 4 Science Collections



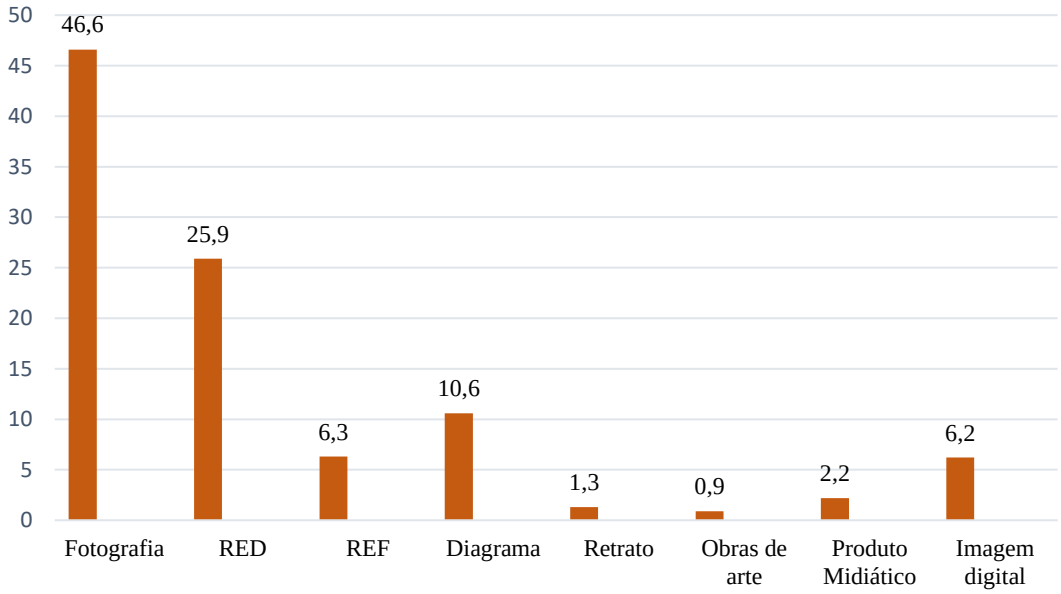
Legend: F – Photograph; RED – Schematic Representations with Drawings; REF – Schematic Representations with Figures; PM – Media Product; a – Visual Representations without People; b – Visual Representations with People.

Source: Prepared by the authors based on the PNLD-2022 textbooks from the sample.

Observing Graph 1, we can highlight the predominance of photograph reproductions,

accounting for 46.6% of the visual representations, which corresponds to 3,158 out of a total of 6,777 found in the four Science textbook collections. When combining the modalities: map, graph, table, diagram, conceptual map, and infographics as diagrams, considering the specificities of this type of representation from the perspective of Peircean semiotics, we identify 720, which represents 10.6% of the total visual representations, as shown in Graph 2.

Graph 2 - Percentage of Visual Representations in the Media Product (PM) Modality, Highlighted for the 4 Science Collections in the Sample



Legend: RED – Schematic Representations with Drawings; REF – Schematic Representations with Photographs.

Source: Prepared by the authors based on the PNLD-2022 textbooks from the sample

We selected a collection titled *Ciências Naturais: aprendendo com o cotidiano* (Canto, Leite, Canto, 2022) among the four Science collections that comprise the sample. We will analyze tables, graphs, infographics, maps, and conceptual maps found in this selected collection, following the classification of signs presented in speculative grammar, as previously mentioned.

Before proceeding, it is necessary to explain how data is presented in these types of visual representations. Tables and charts generally present data in a summarized manner, facilitating the understanding of the studied phenomenon. According to the *Normas de Apresentação Tabular* (Tabular Presentation Standards) (IBGE, 1993), in a table, the central information is numerical data, which is accompanied by a title, header, content, source, and, if necessary, explanatory note(s)

(general and/or specific), with open side borders. On the other hand, a chart, while following similar specifications (title, source, legend, note[s], and other necessary information), has closed sides and no limit on horizontal lines. A chart is also considered an illustration, as stated in NBR (14724: 2011, p. 15):

> [...] Regardless of the type of illustration, its identification appears at the top, preceded by the designated word (drawing, diagram, flowchart, photograph, graph, map, organizational chart, blueprint, table, portrait, figure, image, among others), followed by its sequential number in Arabic numerals, a dash, and the corresponding title.

The infographic, another form of visual representation found in textbooks, is also a sign that combines verbal and visual languages by employing words and images. Due to its capacity for synthesis, this form of representation is widely used in business reports and catalogs, science, physics, engineering, statistics, advertising, product design, face-to-face and online education, information technology, communication and entertainment companies, instruction manuals, scientific dissemination, and journalism. In the current context, advances in computing and graphic software have opened new possibilities for producing infographics.

There are several taxonomies for infographics, such as Peltzer's (1991), which divides infographics into view infographics, explanatory infographics, and infographic reports; Colle's (2004), which proposes eight modalities; Sancho's (2001), which classifies infographics into individual and collective, with four subdivisions for each modality; and finally, Ribas's (2004), which categorizes online infographics by type, state, and category (sequential, relational, and spatial). These classifications, however, do not focus on the interpreter's thought process but rather on the elements that compose the infographics.

Here, we will adhere to the classification proposed by Colle (2004), which divides infographics into eight modalities: 1) Diagram Infographic: combines diagrams and pictograms and is considered the first and simplest type of infographic, as despite containing the same content as a statistical table, it is much more suggestive, easier to read, and quicker to grasp and memorize; 2) Enlightenment Infographic: presents texts accompanied by pictograms or icons and is considered an infographic due to its general appearance: a visual unit within a rectangular frame presenting verbal and iconic content, though the text does not follow principles of a single sequential discourse; 3) Info-map: maps that combine icons and text, which can be economic (local and industrial productions) or thematic (e.g., tourism); 4) First-level Infographic: primarily consists of a title, anchor text, and an illustration,

which may include identifying words superimposed on maps and charts, while the texts remain entirely peripheral to the infographic; 5) Second-level Infographic: features an icon where the text becomes a dynamic part of the infographic, as seen in comic strips; 6) Spatio-temporal Sequence: infographics that depict the progression of an event over time, where the various stages are presented in a single graphic, using spatial sequence as a way of representing temporal sequence; 7) Mixed Infographics: combine various types of graphics, resulting in multiple combinations; and 8) Mega Infographic: the most comprehensive infographic, containing abundant information, disregarding simplification and space economy rules, and generally occupying a full page or two pages of a newspaper or magazine.

Regarding the conceptual map another form of visual representation found in the selected Science textbook collection it is worth highlighting Novak's (2000) studies, which developed the concept of the conceptual map based on Ausubel's Theory of Meaningful Learning. Novak (2000) demonstrated that, to some extent, the conceptual map represents the outline of this process, considering that cognitive structures can be hierarchically organized, can achieve greater breadth and specificity concerning a concept, can promote the relationship of this concept with others, and, finally, can facilitate integrative reconciliation when two or more concepts are related, generating new meanings.

As Lima (2004, p. 135) explains, the conceptual map “involves identifying concepts or ideas related to a subject and describing the relationships between these ideas in the form of a schematic drawing.” Referring to the teaching/learning process, Novak (2000) clarifies that conceptual maps can be used as tools to observe how students progressively attach meanings to the concepts represented in these maps.

For Novak (2000), a good conceptual map should display concepts and establish connections between them using linking elements propositions expressed clearly and concisely. It should present relationships in a straightforward manner while adhering to principles of visual language, highlighting both hierarchical relationships and the propositions and cross-links between them. Conceptual maps fall into four types: “spider web,” flowchart, system type, and hierarchical. The first, the "spider web" conceptual map, places the main concept at the center, with related ideas or complements arranged around it, forming a "web." The second, the flowchart, illustrates a step-by-step process. The system-type conceptual map is a flowchart enhanced with inputs and outputs, representing a system. Lastly, the hierarchical conceptual map displays the most critical information at the top, followed by subsequent information in decreasing order of importance.

Regarding the purpose of conceptual maps, Lima (2004) explains that they, through the compilation and analysis of information, can aid in idea generation; outline structures that contribute to understanding the complexity of texts, documents, hypertexts/hypermedia, and websites; present ideas graphically, which can enhance communication and the teaching/learning process by integrating new and existing knowledge; and facilitate idea comparison.

To analyze these diagrams, we will rely on aspects of speculative grammar, a branch of semiotics or logic proposed by Peirce. This approach suggests that education, by reconfiguring teaching/learning processes, can align itself with Peircean semiotics.

Theoretical Contributions

The presence of visual representations in textbooks plays a highly significant role. This is evident when analyzing the data in Graph 1, which suggests an average of approximately two visual representations per page, considering an average length of 200 pages per book. It is important to emphasize, as highlighted in the introduction, that these visual representations cannot simply be interpreted as secondary illustrations. In the educational context, this observation underscores the need for schools to cultivate skills related to visual language.

Dondis (2015) clarifies that visual literacy is as vital for education today as reading and writing were for printed text. The invention of devices such as the camera and cinema, among others, as well as visual media yet to be explored, have not only promoted but will continue to promote transformations in our perspectives on education, impacting our cognitive perceptions. These transformations, therefore, require a revision of our basic visual abilities, the development of a structural system, and a methodology for teaching and learning how to visually interpret ideas. What was once the domain of artists and designers has now become a concern for those involved in visual communication media, their audiences, and, as we emphasize here, educators.

Dondis (2015, p. 6) further reminds us that, from our first experience in the world, we begin to organize ourselves based on what we see or want to see. For this reason, "we accept the ability to see in the same effortless way we experience it." However, this ability can and should be expanded because we are readers of both words/books and images, and both have cognitive potential. The act of reading is not limited to deciphering or decoding words. Since illustrated books and later newspapers and magazines, reading has incorporated “the relationships between word and image; between text, photo, and caption; between font sizes and page layout; between text and design” (Santaella, 2012, p. 10). Santaella goes further, extending the act of reading to messages embedded

in the chaotic landscapes of large urban centers overpasses, lights, traffic signs, and signals—and the profusion of posters, illuminated advertisements, graffiti, and images present in charts, maps, notation systems, and the screens of computers and smartphones. It is only natural that the concept of reading evolves alongside language, and among these, visual language takes a prominent place in the reflections proposed in this article.

To outline the interface between Peircean semiotics and education suggested here, we establish two levels: one that considers school subjects as a language and another that delves into the specificities of these subjects to highlight the relevance of a particular visual representation modality, the diagram. For this purpose, we draw on speculative grammar, which provides definitions and classifications of signs, involving both verbal and non-verbal elements. From this, methodological strategies emerge for reading and analyzing signs and diverse languages, such as school subjects, advertising products, cinema, music, literature, hypermedia, and more. In addition to considering school subjects as language modalities, it is crucial to recognize that media products permeate the educational environment and can be used as pedagogical tools. In this context, speculative grammar, as a guide for applying image analysis strategies, can become a valuable ally for teachers.

Peircean semiotics provides a path for the reader to delve into the materiality of the image as a sign, extracting meanings at each stage of its interpretation. These stages are tied to the three categories underpinning C. S. Peirce's entire theory: firstness, secondness, and thirdness. Embedded within this triadic foundation are the concept of the sign sign, object, interpretant the classification inherent to each of these components, and the triads that emerge within these classifications. Mastery of the terminology is not what truly matters, but rather the logic underlying each stage of interpretation, which unfolds through different modes of observation: first, the gaze that contemplates qualities (firstness); second, the gaze that observes and discriminates between existents (secondness); and third, the gaze that interprets, generalizes, and absorbs cultural patterns.

The logic sustaining this network of signs originates in phenomenology, “a quasi-science whose function is to provide the observational foundation for the rest of the philosophical disciplines” (Santaella, 2001, p. 35). Seeking to categorize experiences as universally as possible, Peirce (1935, CP 5.41) warns us:

> Let it be understood, then, that what we have to do, as students of phenomenology, is simply to open our mental eyes, look closely at the phenomenon, and state what characteristics are never absent from it, whether this phenomenon is something that external experience forces upon our attention, or the wildest of dreams, or the most abstract and general conclusions of science.

From a broad perspective, we present the categories. Firstness refers to quality. Its inaugural nature positions it as the first impression of experience, meaning "it is immediate consciousness as it is. Nothing else but pure quality of being and feeling" (Santaella, 1996, p. 9). The second category, secondness, pertains to otherness. Since it involves a duality (self/other) or dyad, it can be characterized by conflict or opposition. Thus, it encompasses ideas centered on polarity, such as brute force, dependence, conflict, and surprise. Finally, the third category, thirdness, pertains to mediation. It relates to generality, continuity, growth, learning, habit, and, quintessentially, the sign. The evolutionary aspect of thirdness is connected to the process of generating new signs in semiosis, a process of sign production that allows us to interpret the world through representations.

In the hierarchical structure underpinning Peirce's philosophical architecture, directly beneath Phenomenology are the normative sciences, which are also triadic: aesthetics, ethics, and logic or semiotics form its branches. Although logic occupies the third position, it encompasses the previous two. Logic or semiotics deals "not only with truth, [...] but also with the laws of thought evolution, which coincide with the study of the necessary conditions for transmitting meaning from one mind to another" (Santaella, 2001, p. 39). Semiotics or logic is further subdivided into three branches. The first is speculative grammar, which provides definitions of signs and a taxonomy that is not merely nominal but explains how signs function in the mind. A sign 'represents' something to the idea it provokes or modifies. That is, it is a vehicle that communicates something external to the mind. The 'represented' is its object; the communicated, the meaning, the idea it provokes, is its interpretant" (Peirce, 1931, CP 1.339). "The sign is capable of determining the interpretant because it has the power to generate it, meaning the interpretant is an objective property inherent to the sign, whether or not a specific interpretative act actualizes it" (Santaella, 1995, p. 85).

Each of these constituent elements of the sign sign, object, interpretant can be classified into new triads. The sign, as the first element of the triad, has the attributes of quality, existence, and convention. A sign of quality is called a qualisign; a sign of existence is a sinsign (sin = singular); and a sign of generality or convention, sustained by law, is a legisign or sign of law. In relation to its object, the second element of the triad, the sign can be an icon, where the dominant aspect of the relationship is similarity; an index, where the dominant aspect is reference or connection; or a symbol, where the dominant aspect is habit or representation. In relation to its interpretant, the third component of the triad, the sign can be a theme, producing hypotheses through associations of

similarity; a dicent, where reference leads the interpretant to confirm the object, meaning it involves assertion; or an argument, where signs of law ensure its validity.

Thus, based on this definition, we can emphasize that the interpretant is both a sign and the product of an intellectual synthesis. The action of the sign semiosis only becomes effective when it generates another sign, meaning the interpretant does not remain as a potentiality but activates the process of signification.

Those seeking to inventory the possible meanings generated within a sign must employ three types of observation: contemplative, observational, and generalizing, founded on Peircean phenomenology's categories. Respectively, these modes of observation capture the qualitative, referential, and conventional aspects rules, norms, or culturally shared conventions of the sign/object, which form the foundations of the sign.

The first observation allows us to capture the qualitative aspects, which, in a visual sign, are linked to colors, shapes, lines, textures, and the arrangement of these elements. When directed at a verbal sign, other qualities will be observed, from morphological and syntactic levels to discursive ones, particularly in poetry, where qualitative aspects are pushed to their limits. For a sound sign, the qualities are embedded in pitch, intensity, and timbre. The second observation focuses on identifying clues that lead the interpreter to the existents, or the realities in which the object is situated. The third observation captures the conventional aspects rules or norms shared within a culture that permeate the object and, in some way, are tied to the cultural context in which the object functions as a sign.

With these strategies, it is possible to unveil the layers that envelop signs. However, it is important to note that these modes of observation serve as general frameworks for thought and, as such, do not preclude specific knowledge about the analyzed language, whether it be sound, visual, or verbal. From this perspective, we can analyze school subjects as differentiated modalities of language, as well as media processes and products in general. Mathematics or biology, for example, require modes of representation distinct from words, such as tables, graphs, equations, infographics, drawings, and conceptual maps, among others. By broadening the scope or using speculative grammar, educational practices can focus on the process of constructing these signs.

The second level of the education/semiotics interface addressed in this article stems from a more specific look at the classification of signs, which helps to analyze aspects that assist in understanding how certain signs act or how they trigger cognition in the interpreter’s mind. Here, the focus is on iconic signs, particularly diagrams, as previously mentioned.

Hypoicons, or iconic signs, are subdivided into three modalities: image, diagram, and metaphor.

> Images embody simple qualities [...]. Diagrams represent relationships, particularly dyadic relationships or those considered as such between the parts of an entity, by employing analogous relationships within their own components. [...] Metaphors represent the representative character of a sign by drawing a parallel with something distinct. (Peirce, 1932, CP 2.277).

Images suggest objects through similarity, grounded in their appearance. Diagrams require a likeness as they present the relationships between the parts of their object, using analogous relationships within their own components. Metaphors, on the other hand, suggest the object through a comparison between the meanings of an object distinct from the one being suggested.

It is important to emphasize that any type of representation (visual or otherwise) that presents analogous relationships to those of its objects (suggested) is called a diagram. The similarity between the sign and the object is established through shared structural relationships rather than surface appearance, as is the case with images. A "[...] major distinctive property of the icon is that, through direct observation of it, other truths about its objects can be discovered beyond those sufficient to determine its construction" (Peirce, 1932, CP 2.279), which also applies to diagrams, a type of iconic sign.

However, one aspect must be considered: the movement of thought in a diagram always involves conventional signs, given that "[...] any material image, such as a painting, is largely conventional in its mode of representation; yet, in itself, without captions or labels, it can be called a hypoicon" (Peirce, 1932, CP 2.276). The relationships of similarity in hypoicons are traversed by these conventional signs (symbols).

Here, we will analyze tables, charts, graphs, infographics, and conceptual maps as diagrams. Let us examine the pertinence of this classification and how it contributes to understanding cognition involving such iconic representations.

Diagrams in Focus

Below are diagrams selected from those present in the Science collection included in the sample: a table (Figure 1), a map (Figure 2), a graph (Figure 3), a conceptual map (Figure 4), and an infographic (Figure 5). The table (Figure 1), by presenting data in a summarized manner and directing the interpreter's gaze to traverse the horizontal and vertical lines, enables the construction of relationships between the phases of the moon and the times for moonrise and moonset. The table’s title reinforces these possibilities.

Figure 1 - Table

Horários aproximados para o nascente e o poente da Lua		
Fase da Lua	Nascente	Poente
Nova	Seis da manhã	Seis da tarde
Crescente	Meio-dia	Meia-noite
Cheia	Seis da tarde	Seis da manhã
Minguante	Meia-noite	Meio-dia

Fonte: R. R. F. Mourão. *Manual do astrônomo*: uma introdução à Astronomia Observacional e à construção de telescópios. Rio de Janeiro: Zahar, 1995. p. 51.

Source: Canto, Leite, Canto, 2022c, p.158.

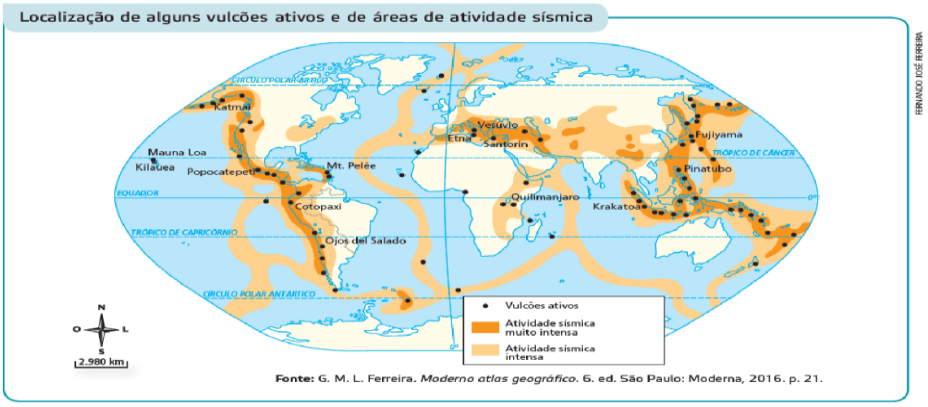
Regarding the relationship between text and image, the semantic classifications established in this dialogue, according to Santaella and Nöth (2020), are: redundancy, where the image duplicates the information already contained in the text; dominance of text or image, depending on the emphasis of informativeness; complementarity, which lies between redundancy and informativeness, characterized by equivalence between the two codes each informing through its specific media potential; and, finally, discrepancy, where word and image are in discordance. The table (Figure 1) under discussion draws the interpreter's attention by interrupting the text flow and, by adding information distinct from that in the text, is classified as complementary.

The table presents relationships between data that contribute to making the object of the sign more apparent. In this case, it is not the appearance that determines the sign's action but rather the relationship between two aspects of the object: the phases of the moon and the times of moonrise and moonset. There are diagrams that "[...] do not resemble their objects at all; their similarity pertains only to the relationships among their parts" (Peirce, 1932, CP 2.282).

In this regard, as a diagram, the table is particularly conducive to cognition and the action of the sign, as it prompts the interpreter's mind to construct relationships between parts of the sign's object, making it, to some extent, present.

Let us now consider a map (Figure 2) from the perspective of a diagram. The relationships that the interpreter can construct as their gaze identifies different continents (or their representations) involve the location of active volcanoes and areas with seismic activity.

Figure 2 - Map



Source: Canto, Leite, Canto, 2022b, p.236.

There are signs embedded in rules, norms, and conventions – symbols - that compose the map, enriching the interpreter's perspective. However, these symbols do not dominate; instead, indices take precedence, establishing a connection with existents and contributing to the map's configuration as a diagram. Additionally, qualitative aspects, such as colors and shapes, hold the potential to evoke a contemplative gaze from the interpret.

Thus, the map qualifies as a diagram because it shows relations of similarity with reality, specifies territories, and points to their particularities. It is not the Earth with its volcanoes and areas of seismic activity, but it stands in for it, making it present through relations of resemblance. The same relationships found among elements in the mapped location must appear on the map, which is achieved through various conventions, such as identifying highways, buildings, comparing magnitudes, distances, and built-up areas symbolic and codified aspects.

In the semiosis involving a diagram, conventions and connections with existents are actualized, helping to stabilize the interpreter's understanding. As previously mentioned, in Peirce's perspective, the relations of similarity in diagrams are generally interwoven with conventional signs (symbols).

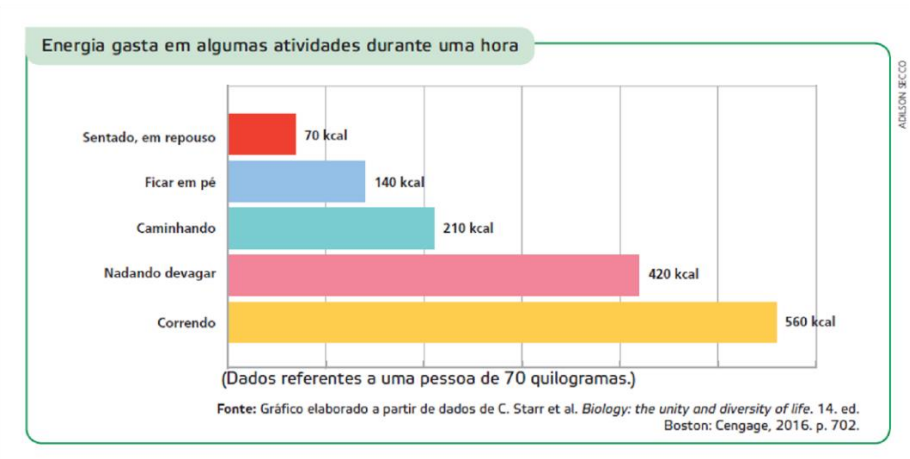
It is worth emphasizing that the diagram surpasses possible verbal descriptions of the phenomenon it represents. No matter how efficient verbal language might be, it would still need to organize these descriptions into a sketch of a map or diagram that, to some extent, could be recognized as a map.

It would be relevant to highlight that, according to Merleau-Ponty (1994), language induces forgetfulness, as the form and sound of words fade before the force of meaning; in other words, the word tends to prevail as a symbol. "This certainty we have of reaching, beyond expression, a truth

that can be separated from it and of which expression is merely its garment or contingent manifestation, is precisely what language has instilled in us" (Merleau-Ponty, 1994, p. 458).

In this sense, the meanings generated by the symbols that make up a map, along with the indices that connect to existents, merge in the interpreter's mind, allowing them to construct a form or a pattern of similarity relations: the diagram. Let us now consider a graph (Figure 3).

Figure 3 - Graph



Source: Canto, Leite, Canto, 2022c, p. 30.

Once again, a phenomenon (the object of the sign) becomes present through numerical data, primarily in a gradual comparison between categories. This presence is consolidated when the interpreter understands the graph, that is, when they establish the relationships between the elements of the phenomenon represented in the graph. The title and supplementary information provide context for the phenomenon, which involves the energy expenditure by a person weighing 70 kg in various physical activities over the course of an hour. In this case, conventions- rules, norms, and concepts - are intertwined with indices to make the phenomenon present.

Indices predominate through the words (on the left side of the bars) and the numbers, followed by units of measurement (on the right side of the bars). Symbols, represented by the colored bars, derive from mathematical and statistical concepts. In the graph, the deciphering of symbols is more demanded than in the previous diagrams. However, in the process of interpretation, it functions as a diagram because it presents the phenomenon as the interpreter constructs possible relationships and makes the phenomenon present.

Thus, the graph also prevails as a diagram. As Silveira (1989) explains, a diagram possesses a constructive, and therefore synthetic, nature, and maintains a resemblance between the form of the

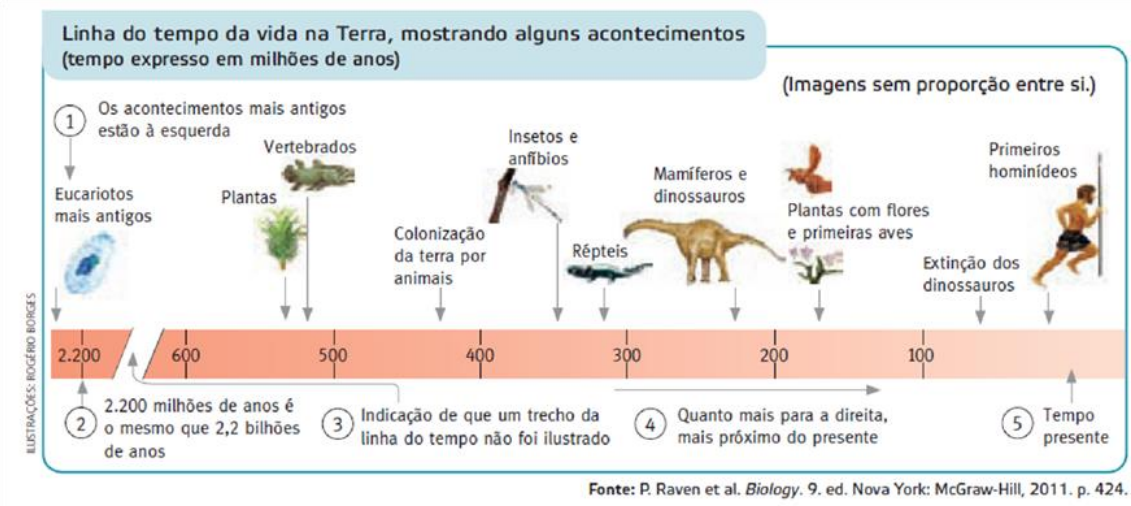
relationships among its parts and the relationships among the parts of the possible object. This makes it a logical construction with an iconic character. This iconicity enables the diagram to foster the potential for expanding knowledge. Such similarity is structural and limited to a specific set of elements within the object, with the focus placed on the relationships between these elements.

Beyond the specificities listed for tables, graphs, and maps such as their synthetic nature and their attempt to present the object through similarity beyond mere appearance infographics are also characterized by their incorporation of visual representations and numerous indices (arrows, numbers, colored bands) that guide the viewer's gaze through the entire composition. Let us now examine the infographic (Figure 4).

According to Colle's (2004) classification, mentioned in a previous section, this infographic falls under the spatio-temporal sequence modality, as it illustrates the progression of an event over time, with its various stages presented within a single graph. This spatial sequence serves as a representation of the temporal sequence

.

Figura 4 - InfoGraph



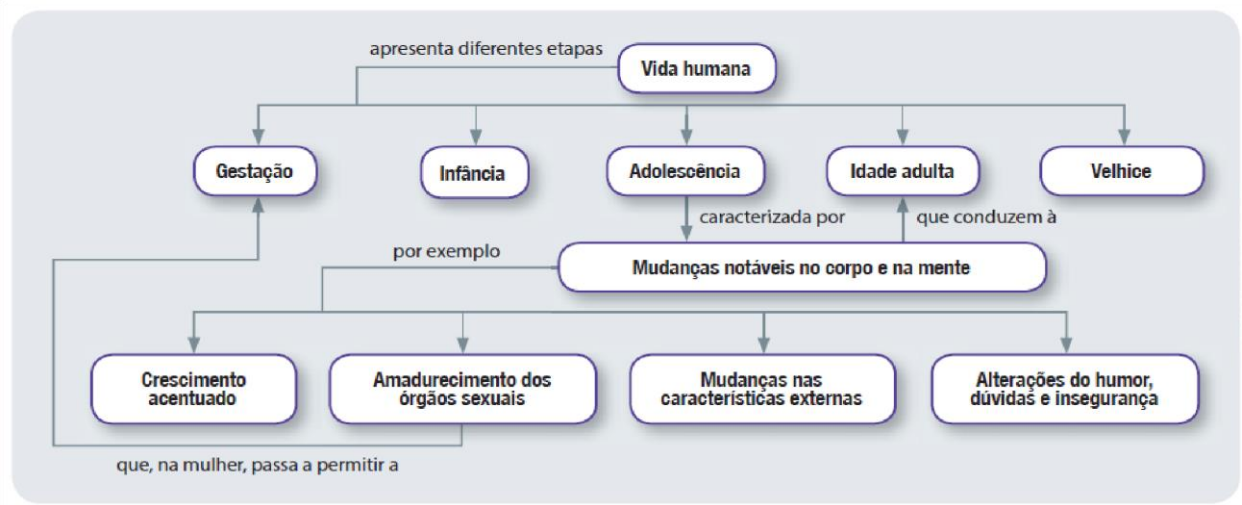
Source: Canto, Leite, Canto, 2022d, p.232.

The object becomes present as the interpreter's gaze, compelled by the qualitative aspect of color - a pink band - is prompted to follow it, guided by the connections imposed by indices - circled numbers and arrows - along the timeline and the life that existed on Earth during those periods. Additionally, arrows direct the gaze to the names and visual representations of different types of life on Earth which, through redundancy, reinforce the relationship between the period and the type of life that existed.

This movement, facilitated by visual representations (images, in the Peircean perspective), words (symbols), and various indices, constitutes a diagram by making aspects of life on Earth present. From a logical perspective, in the action of the sign, it functions as a diagram.

In the infographic (Figure 4), the connection to codes is weaker than in the graph (Figure 3). It is worth noting that the presented schema already displays the relationships between the elements of the phenomenon, leaving it to the interpreter's mind to reaffirm these relationships during the action of the sign. Additionally, there is the possibility for the gaps highlighted in the infographic to be further explored for instance, if the interpreter seeks knowledge about the plants and reptiles that existed here before the appearance of humans. This confirms the diagram's potential to expand knowledge. Finally, let us examine the conceptual map (Figure 5).

Figure 5 - Conceptual Map



Source: Canto, Leite, Canto, 2022c, p.20

According to Novak's (1995) definition, the visual representation above (Figure 5) is a conceptual map because it presents concepts and establishes hierarchical links between them. Due to its structure, it is classified as a flowchart. In this case, the map outlines the stages of life and identifies the changes in the body and mind associated with each period, thereby constructing a framework that aids in understanding the ideas presented in the accompanying text.

From a Peircean perspective, the conceptual map can be viewed as a diagram precisely because it highlights the relationships constructed between life stages and the development of the mind and body during these period.

Final considerations

The diagram - viewed here under specific denominations: table, chart, map, graph, infographic, and conceptual map - communicates with brevity and conciseness, showcasing precision, accuracy, and refinement. However, despite its brevity, it demands a prolonged gaze one that decodes conventions and is guided by indices to uncover a form, the structure underlying the object of the sign. In this process, the object becomes present. The force that makes the object present contributes to triggering cognition or a certain interest in intelligibility. This involves recognizing and identifying conventional aspects, connecting them to existents, and organizing the form the diagram.

Considering the substantial number of visual representations in these Science textbook collections and the fact that they cannot dispense with diagrams - particularly infographics - to facilitate the understanding of topics in this discipline, it can be noted that the proportion of infographics 10.6% of the total visual representations is relatively small compared to other modalities, such as photograph reproductions, which make up 46.6% of the total, as shown in Graph 2.

Finally, it is worth emphasizing that the potential of diagrams is not fully explored in the composition of texts or activities. Generally, they are treated as illustrations, with the potential to reinforce the meanings of the topics covered, which is also important for student learning. However, in most cases, they do not appear as drivers of learning, with the potential to prompt discoveries by the student or to guide the development of the subject matter.

In light of this, educators should reflect on the possibility of exploring the diagram's potential to create an environment conducive to the interpreter's mind, fostering the formulation of conjectures, the development of hypotheses, and the experience of (re)constructing new knowledge.

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