



# Enhancing Science Education Through Visual Art and Complex Storytelling Using the Book “The Case Study of Einstein, Eddington, and the Eclipse: Travel Impressions”

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## Abstract

This paper delves into the innovative integration of arts in science education, as exemplified by the book *Einstein, Eddington, and the Eclipse: Travel Impressions*. The book uniquely combines a history of science essay and a graphic novel, collaboratively created by Ana Simões, a historian of science, and Ana Matilde Sousa, an artist. Diverging from conventional science communication comics, the graphic novel section adopts an “art comics” style, with experimental aesthetics and complex storytelling, challenging the notion that comics oversimplify scientific concepts and events. This paper primarily focuses on the creative processes, themes, and decisions involved in the making of the graphic novel, showcasing how it synergizes with the essay to present a rich tapestry of the global context, societal impact, and diverse individuals involved in the 1919 British astronomical expeditions which proved Einstein’s light bending prediction. Additionally, this paper also serves as a practical resource/tool for educators, offering a “skeleton key” that engages students, particularly science undergraduates, in critical thinking about scientific and historical content. It underscores the significant role of visual arts in enriching science education and highlights the book’s contribution to the evolving landscape of STEAM education.

## 1 Introduction

In the field of science education, there exists a notable shift in pedagogical approaches, with a strong emphasis on interdisciplinary techniques and the use of creative teaching resources, especially concerning arts-based science education. As Lauren Madden and colleagues put it “in recent years, integrating arts into science or science, technology, engineering, and mathematics (STEM) instruction has received much attention, resulting in a new buzzword: STEAM, in which the ‘a’ stands for ‘arts’” (Madden et al., 2022: para. 3). STEAM education aims to transcend disciplinary boundaries, nurturing increased creativity and crucial skills in

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students, including but not limited to critical thinking, adaptability to complex contexts, the ability to identify potential biases, and a comprehensive understanding of the cultural, social, and ethical dimensions intertwined with the generation of scientific knowledge and practices (Field et al., 1994; Kavaloski, 1979; Madden et al., 2022; Paranjpe, 2022). The present paper contributes to this evolving landscape by addressing the distinctive contribution of the book *Einstein, Eddington, and the Eclipse: Travel Impressions*, about the two British astronomical expeditions, one of which headed by the astrophysicist Arthur Stanley Eddington that confirmed Albert Einstein's prediction of light bending put forth by his general theory of relativity. The book was published in 2019 by Chili Com Carne (CCC), a prominent Portuguese association that promotes artistic diversity and experimental approaches within the medium of comics. A second edition, released in 2023 and available in open access, includes 16 additional comic pages, along with two modified pages, that extend upon the original content (Simões & Sousa, 2019, 2023).

The book, as well as this accompanying paper, stand out for several reasons. Firstly, *Einstein, Eddington, and the Eclipse: Travel Impressions* combines a history of science essay and a graphic novel into one volume, a unique blend made possible through the collaboration of Ana Simões, a historian of science, and Ana Matilde Sousa, an artist. Secondly, this paper stands as a complement and an integral component that enriches the overall educational experience created by the essay and graphic novel. Together, these three elements—essay, graphic novel, and paper—form a cohesive triad aimed at enhancing the communication of and education in science. While the essay provides the academic and historical context, and the graphic novel offers a visually engaging narrative, this paper functions as the pedagogical bridge that connects and amplifies their educational impact.

A key aspect of the *Einstein, Eddington, and the Eclipse: Travel Impressions* that has sparked interest among readers, students, and critics alike is the approach to the graphic novel itself, which is 128 pages length in the original and 144 pages in the extended version. This section of the book diverges from the conventional styles typically found in comics focused on science education and communication; instead, it offers a fusion of science communication with “art comics”—a genre of comics known for their “experimental” or “conceptual” nature (Moura, 2013: para. 2-3, 2020: para. 1; Farinelli, 2018). Indeed, the graphic novel section of *Travel Impressions* addresses a significant gap identified by Mico Tatalović in science communication comics, including those on the history of science, by countering the common trend towards an “uncritical promotion of science, even scientism, as well as clichés and established top-down narratives” (Tatalović, 2022: para. 4), despite the growing popularity of such comics (Doxiadis et al., 2009; Padua, 2015; Villani & Baudoin, 2015).<sup>1</sup> This tendency is likely tied to the common misconception that comics inherently simplify or “dumb down” complex subjects to make them more accessible, disregarding the reality that comics, like any artistic medium, encompass a broad spectrum of complexity and depth. The essay-graphic novel project was aimed to broaden the scope of science communication comics by developing a graphic novel that reinterprets a significant historical event with experimental aesthetics and complex storytelling strategies, thereby challenging readers by encouraging a more thorough engagement and thought than usual. To equip educators with a comprehensive toolkit—including a history of science essay, an experimental graphic novel, and this analytical paper—to nurture their students' creativity and critical thinking, this paper offers in the subsequent sections a reflection on the process, structure, and significance of the intentional choices behind the book.

Intended primarily for use in college classrooms and secondary schools through discussions or activities, by unpacking the book's creation process, this paper also may inspire potential authors to experiment with a more holistic, interdisciplinary educational

approach. Aligning with contemporary trends in scientific education, focusing on diversity, accessibility, equity, and quality,<sup>2</sup> through the integration of social, cultural, economic, and environmental factors across various geographic scales, from local to global (UNESCO, 2005, 2006, 2014a, 2014b, 2020), the book, with its graphic novel component, also exemplifies how such works can contribute to research in the history of science, as its publication is part of the broader project *E3GLOBAL. Einstein, Eddington, and the Eclipse. A global history of the total solar eclipse of 1919*. As such, it embodies the concept of a multidisciplinary research practice that marries science, education, and the arts in a cohesive research output.

In what follows, after a section introducing “Methodological considerations,” we concentrate on specific segments of the graphic novel that exemplify a close engagement with contemporary trends in science education, moving towards narratives that are more diverse and less centered around singular heroic figures. In “Both Essay and Graphic Novel: The Book’s Materiality,” it is explored how incorporating Eddington’s letters influenced the overall narrative structure, including how it facilitates an in-depth understanding of the daily life experiences of travelers and how they are impacted by scientific actions, decisions, and outcomes. It is also addressed the significance of the graphic novel’s bilingual format, and of the application of tradigital methods in the artistic development of the comic pages. Next, in the section titled “Depicting Empire, Uncovering Invisibilities,” the creative choices made to address the scientific expedition as a network of varied, human and non-human, actors are discussed, showcasing various cultural and linguistic contexts that transcend the traditional focus on European nations. This includes a discussion of how it was determined which characters to represent and how visible they should be, emphasizing those typically underrepresented in conventional historical narratives and redirecting attention away from prominent figures. “Singularizing the Total Solar Eclipse” focuses on the recurrence of the eclipse imagery in the graphic novel, tracing its depiction through various iterations, from the actual event to the photographs captured by Eddington and his team. In the final section, “Bringing Back into the Picture the British Expeditioners at Sobral,” it is examined how the graphic novel, primarily centered on Eddington’s expedition to the tropical island of Príncipe, integrates the sister British expedition to Sobral into its narrative tapestry. The paper wraps up with a series of concluding remarks.

## 2 Methodological Considerations: the Importance of History of Science in STEM and Visual Arts Practice-Based Research in STEAM

In this part, we seek to clarify two key elements: the importance of the history of science in the context of science education, and the reasoning for writing an analytical paper about an artistic work—the graphic novel in *Einstein, Eddington, and the Eclipse: Travel Impressions*. Discussing these aspects has educational value for readers, particularly for advocates of arts-based science education, STEAM approaches, or those navigating the intersection of artistic creation and academic research themselves.

In recent decades, the role of history of science in teaching science undergraduates has evolved significantly. Earlier concerns, such as those raised by S.G. Brush in 1974, warned of the potential unease science undergraduates might experience when encountering historical perspectives that challenged traditional positivist narratives. These narratives typically depict “great” scientists as solitary heroes and portray science as the epitome of

universal, objective, and neutral knowledge. Brush went as far as to state that history of science should be deemed as contentious as X-rated material for teaching in undergraduate science programs (Brush, 1974). In contrast, beginning in the 1980s, a significant change has emerged, fuelled by the increasing awareness of the importance for future scientists to comprehend the historical backdrop of scientific advancements and the societal influences behind them—a shift that, for instance, acknowledges that the practitioners of science extend beyond the major figures of the past. Such a reorientation prompted renewed discussions on the use of history of science in undergraduate science education, which found expression in associations' forums and journals, and were included in pedagogical reforms in UK and in the USA. The International History, Philosophy, and Science Teaching group (IHPST), along with its affiliated journal *Science and Education*, played a pivotal role in this discourse. More recently, directives by the European Union have emphasized the importance of incorporating disciplines from the social sciences and humanities into the education of science and engineering undergraduates, with history of science courses standing among them.

Several proposals have been put forward recently concerning the uses of history of science in teaching science undergraduates. Graeme Gooday et al. (2008) point to the acquisition of essential skills, such as interpreting primary sources and enhancing critical thinking, grounded on the initiation to the subculture of their chosen scientific field as well as on understanding its past cultural settings. Another instance is the recent FOCUS section of journal *Isis* dedicated to pedagogy, with introductory remarks by Karen Rader on “The changing pedagogical landscapes of History of Science and the “Two Cultures,” reviewing how pedagogical approaches to history of science have “shaped and been shaped” by the changing relations between the humanities and the sciences in colleges and universities (Rader, 2020: 568). Among the various proposals discussed, one noteworthy approach is Daniel Gamito-Marques's utilization of storytelling techniques to actively engage students in thinking about how concepts and theories evolve (Gamito-Marques, 2020). His approach aligns closely with arts-based science education and is particularly relevant to the graphic novel, for comics, as a medium, effectively combine storytelling with visual arts like drawing and painting.

This raises another important question—how can an analytical paper that details the criteria and methods used in producing a book, particularly its graphic novel section, contribute meaningfully to the field of science education? While this paper's approach may be different from traditional research in science education, the type of research involved in writing academically about the creation of an artistic work has long been a staple of practice-based research (PBR) in the visual arts, as well as in the arts in general. This approach is recognized for its value in offering deep insights into the creative process, methodologies, and conceptual frameworks that underpin artistic works (Biggs & Karlsson, 2012; Candy & Edmonds, 2017; Hickman, 2008; McNiff, 2013; Smith & Dean, 2009). Therefore, this paper provides science educators interested in enhancing their teaching methods and curricula through interdisciplinarity with a case study of how the interplay of science, history, and the arts—especially, experimental approaches to art and storytelling that add complexity and depth, challenge readers, and promote critical thinking and engagement with the materials—can steer both students and general readers towards complex philosophical inquiry and fresh perspectives on science and its practitioners. Moreover, by unpacking a selection of key moments from the collaborative process of developing the graphic novel, which involved significant transdisciplinary efforts in terms of both content and artistic representation, it is hoped to encourage a similar level of critical engagement in students. As complements to each other, *Travel Impressions* and this accompanying paper

constitute a one-of-a-kind contribution to the field of science education within the STEAM framework, demonstrating the transparent and reflexive nature of practice-based research in the arts, where a graphic novel serves as a tool to explore, tackle, and convey multifaceted research questions originating from the history of science.

### 3 Both Essay and Graphic Novel: the Book's Materiality

#### 3.1 The Role of Eddington's Correspondence

As mentioned in the “[Introduction](#),” the book *Einstein, Eddington, and the Eclipse: Travel Impressions* comprehensively explores the two British astronomical expeditions that confirmed Albert Einstein's prediction of light bending, one of the three astronomical predictions put forth by his general theory of relativity.<sup>3</sup> Coordinated by the Astronomer Royal Frank W. Dyson and the astrophysicist Eddington, these expeditions were the first successful observations of Einstein's light bending prediction (Dyson et al., 1920), following less well-known failed attempts.<sup>4</sup> Eddington and Edwin Cottingham travelled to the island of Príncipe, a former Portuguese colony in Africa (now part of S. Tomé e Príncipe), while astronomers Andrew Crommelin and Charles Davidson set out for Sobral, in Brazil. The book provides a complementary perspective to the canonical narratives of this famous scientific episode,<sup>5</sup> deliberately de-centering the narrative from Einstein and his subsequent rise to popularity after the expeditions to recenter it on a joint comparative assessment of the two British expeditions.<sup>6</sup>

The essay and graphic novel both deviate from the usual scientific topics addressed when discussing Eddington's involvement in the expeditions in relation to his early advocacy of relativity (Stanley, 2003, 2007). Instead, they align with contemporary science education approaches, presenting the student or reader with stories from the history of science that allow audiences to connect with Eddington (the central narrator, as will be further discussed) by immersing them in his experiences and emotions throughout his journey. The graphic novel visually reconstructs the journey of Eddington's team, compensating for the lack of photographic documentation, by primarily utilizing selected excerpts from eight letters sent by Eddington to his mother and one to his sister, with whom he lived, and with whom he shared a close familial relationship.<sup>7</sup> In coordination with the essay that frames it, this storytelling strategy (Gamito-Marques, 2020) creates an impressionistic depiction of everyday events, sensations, food, and people, illustrating the day-to-day experiences of an astronomer on an eclipse expedition. The significance of this facet is often underappreciated, yet it is essential for a more holistic grasp of the scientific process; the graphic novel captures it in a sensory-rich manner, through deliberate narrative and visual choices, thus providing a valuable addition to the typical information found in diaries, memoirs, or personal correspondence.

Additionally, the letters mention several astronomical aspects, including new and enlightening details that can answer historical questions, including the precise location of the expedition's astronomical setup (Latas et al., 2020) and the identities of observers who witnessed the total eclipse with Eddington and Cottingham (Simões, 2022a: 594), which have both been notably missing from the traditional, canonical narratives (Kuchinskaya, 2012, 2014). These are crucial scientific issues that previously went unanswered.

Most of the text in the graphic novel is lifted from Eddington's personal letters, but official letters exchanged with the director or vice-director of the Lisbon Astronomical

Observatory were also incorporated. These official letters focus on the logistics of the expeditions, and requests for information and assistance in arranging the teams' journeys. They are strategically placed at the beginning, middle, and end of the narrative for two reasons: one is to introduce deliberate breaks from the intimate tone set by the private letters (Simões & Sousa, 2019: 65-72, 139-141, 189-192; 2023: 65-72, 147-149, 205-208). Another reason is to provide a solution for framing the beginning and end of the narrative, which was accomplished by selecting Eddington's first and last letters to the Lisbon Observatory as the narrative's opening and closing points.<sup>8</sup> Such a choice underscores the pivotal role of support and knowledge from peripheral actors and institutions in orchestrating the expeditions (Simões, 2022a). Employing the letters in this manner also serves to spotlight the collection of Eddington's correspondence preserved in the Lisbon Observatory archives, of which there are no copies in Eddington's archives and consequently were unknown to the broader scientific community until the publication of the book.

Finally, the decision to use excerpts from Eddington's letters as the text in the graphic novel established an engaging relationship with the collection hosting the book at Chili Com Carne. Indeed, *Einstein, Eddington, and the Eclipse: Travel Impressions* was included in the Low CCCost collection, dedicated to travel-themed comics, often depicted in autobiographical style and narrated in the first person by living authors, usually artists. The eighth installment in the series was the first to delve into the travel experiences of a historical figure, specifically an astronomer, rather than a contemporary artist. As such, it was only fitting for Eddington to narrate the journey in his own words, allowing him to "speak" to today's readers, and bridging the gap between past and present.

In the 2023 edition, this rationale was extended by adding four extra pages featuring extracts from a frequently overlooked letter written by Cottingham on 9 May to the Royal Astronomical Society, in which he describes impressions of the island and preparation works (Cottingham, 1919). By incorporating Cottingham's "voice" alongside Eddington's, the narrative was further enriched with diverse recollections of the expedition (Simões & Sousa, 2023: 166-169).

### 3.2 The Two Languages of the 1919 Eclipse

One of the notable features of *Einstein, Eddington, and the Eclipse: Travel Impressions* is the fact that it is a bilingual publication, in Portuguese and English, a choice that was crucial in shaping the book's concept and structure. The essay, which was originally written in Portuguese by Ana Simões, was translated into English; concurrently, Eddington's letters in the graphic novel, initially in English, were translated into Portuguese; and both Portuguese and English versions of these texts were included in the book. In terms of structure, the book opens with the essay in Portuguese, transitions to the graphic novel in the middle, and ends with the English version of the essay. This setup positions the graphic novel as a linguistic and physical bridge between the two essays, a distinction that is visually and materially emphasized by using different paper types: a yellowish paper for the essay and a whiter, thicker paper for the comic. It was also decided to sidestep the standard method of presenting translations in comic books, where the text in speech balloons is translated into another language either by placing the translation at the bottom of the respective pages or at the end of the book. Instead, English and Portuguese texts were combined within the same "balloons," reimagined as post-its (to be elaborated on later), using a "/" to separate them, with the original English text (Eddington's own) in bold appearing first, and the Portuguese translation coming after the slash.

The focus on a bilingual narrative was driven by conceptual and practical reasons. On the one hand, it is meant to evenly depict the two official languages—English and Portuguese—present across the various locations visited by the British teams, thereby ensuring a balanced portrayal of both. The cover flap of the book maps out the route of the expeditions, indicating that in addition to starting and ending in the UK, the journeys passed by and/or stopped in Portuguese-speaking territories: Lisbon, the capital of Portugal; Funchal in Madeira; Sobral in Brazil (a former Portuguese colony); and the African islands of Cape Verde and Príncipe, which were then Portuguese colonies.<sup>9</sup> The adoption of a bilingual format also symbolized the collaborative ethos shared among British, Brazilian, and Portuguese astronomers, an essential characteristic of the expeditions as described in the essay.

On the other hand, motivated by a commitment to inclusivity, reflecting its growing importance in science education and in line with broader societal and educational shifts, we aimed to make the book accessible to students from diverse linguistic and geographical backgrounds. English, being a global lingua franca, enabled us to reach a wider audience, while Portuguese ensured its greater accessibility to readers in Portugal and in Portuguese speaking countries, including São Tomé e Príncipe and Brazil, where English fluency is less common. This consideration was especially relevant for the book's circulation *now*, one hundred years after the eclipse, and for its potential application in various scenarios, including academic/educational settings.

Nevertheless, it is important to recognize that the languages used during the expedition extended beyond just English and Portuguese. For example, as we discuss later, Eddington and the manager of the Sundry plantation talked in cursory French, and it is probable that the plantation workers communicated with the owner and manager in Creole. Highlighting the use of these additional languages to students demonstrates the plurality of languages and contexts that have historically contributed to science and continue to do so today.

### 3.3 Travel Impressions Through Tradigital Techniques

The graphic novel adopted a “tradigital” art style, which is a hybrid of traditional and digital artistic techniques, albeit with a modification. Normally, tradigital art is initiated with physical sketches that are later digitized and colored, but in the graphic novel, this standard workflow was reversed. The process started by collecting photographic materials from various sources, including archival images, stock photos, public domain images, and photographs taken by the authors, which were then digitally assembled into the comic pages. At this stage, the author-artist deliberately interfered with the functioning of her home inkjet printer by agitating the paper sheets as they were being used to print the comic pages. This action caused various imperfections and irregularities—including smudges, tears, mismatches, and overlaps—while the use of tracing paper, less absorbent than regular paper, further intensified such distinctive effects. After this, the resulting pages underwent several additional procedures. These included being dipped in water to dilute the printing ink, resulting in spills and watercolor-like stains, as well as being rubbed with various tools to scratch the print. In some cases, paints were also applied to certain portions of the pages. Additionally, tampering with the printer caused the print heads alignment to become awry, leading to frequent realignments and numerous test pages. For the second edition, it was included one of these trial pages alongside Cottingham's letter to echo the narrative about an accident with a photographic developing fluid (Simões & Sousa, 2023: 168).

The final stage of page composition involved affixing the post-its with printed computer text onto the pages, substituting the usual speech balloons in comics. As

previously noted, most of the text in the graphic novel is derived from Eddington's letters, which were, naturally, originally written by hand on paper. These "impressions" of Eddington's words on the post-its evoke the notion of leaving a message in passing, or the act of adding notes on top of images when brainstorming a project. We decided to physically print the post-its instead of digitally overlaying the text, so the pages in the book are facsimiles of the original pages. When teaching in classrooms primarily composed of science students, it has been noted that having the opportunity to display the completed originals often leads to significant success and curiosity from audiences. Finally, the pages were scanned and given a slight digital treatment using Photoshop, aiming for a close facsimile of the originals (Fig. 1).

The tradigital technique outlined above lends a dual significance to the book's subtitle, *Travel Impressions*, alluding to both Eddington's impressions during his journey and the materiality of the comic itself, whose pages are literally the result of printing on paper. Furthermore, the "glitches" in the printed pages symbolize the sensory and affective experiences that are a vital part of any journey, including the transient impressions triggered by our senses—sight, sound, smell, touch, and taste—which, although incapable of being fully articulated verbally, are nevertheless fundamental to shaping human thought and knowledge of the world. These imperfections in the graphic novel reflect the radically subjective and fragmentary nature of memory, often lacking the desired clarity and accuracy even when connected to an ostensibly "objective" medium like photography. Thus, the graphic novel, through its aesthetic depiction of the fallibility of memories, even those of scientists, infuses a human dimension into the story of scientific pursuits and the people behind them. While this may go unnoticed by many readers, its significance can be effectively emphasized in a classroom setting by science educators.

Another artistic detail is the use of color in the post-its. Most post-its are yellow, representing Eddington's "voice" and creating a conversational feel with the reader/student. Green post-its are sparingly used to denote historical figures, dates, or days, and to mark excerpts written by the



Fig. 1 The making-of



authors of the graphic novel, rather than sourced from Eddington's letters. But there is an outlier: one page in the book displays a distinct pink post-it (Simões & Sousa, 2019: 122; 2023: 124). The sole image on this page is a photo captured by Ana Simões during the centenary celebrations on the island of Príncipe, in 2019 (Fig. 2a). It pinpoints the precise location of the observational site at Sundy plantation, which in the past had been marked by incorrectly placed commemorative plaques. This accurate identification was the result of transdisciplinary teamwork by a historian of science, a mathematics' teacher, and an architect, and was signaled by an intervention by the local artist Eduardo Malé (Latas et al., 2020). Unlike other photographs in the graphic novel, this specific image was left untouched digitally to singularize it; thus, one important invisibility signaled in the essay, specifically the exact site of the installation used in the eclipse's observation, receives a subtle yet distinct emphasis in the graphic novel. There is yet an additional invisibility highlighted in the essay, and which the graphic novel addresses: the re-creation of the experimental setup in Príncipe, including tents, a telescope, and a coelostat (Simões & Sousa, 2019: 168, 174; 2023: 180-184, 190) (Fig. 2b). Unlike Sobral, no surviving photographs of this setup exist. The graphic novel's second edition includes a distinctive two-page, borderless spread image—the only instance in the entire book—presenting a 3D model of the reconstructed installation. The model, itself, resulted from a collaborative effort involving Duarte Pape, Luís Tirapicos, Samuel Gessner, Hugo Soares, and other members of the E3GLOBAL team (Simões & Sousa, 2023: 181-184). For the graphic novel, artist Ana Matilde Sousa took screenshots of the model from various virtual angles and distances to the astronomical instruments. She then digitally altered, printed, and manually intervened on these images, as she did with all other pages.

## 4 Depicting Empire, Uncovering Invisibilities

### 4.1 Defacing Einstein and Eddington, Visualizing the Invisible Plantation Workers

The exploration of historical invisibilities forms a central part of both the essay and the graphic novel, echoing the recommendations in science education to humanize science and recognize the myriad of actors who, to a greater or lesser extent, participate in the scientific enterprise. Many of these individuals have been obscured in historical narratives by their contemporaries and science historians for reasons that demand exploration, decoding, and understanding.

The graphic novel avoids the typical visual depiction of well-known historical figures, a common element in traditional science communication comics. Indeed, apart from the portraits of the expeditioners at the beginning of the comic,<sup>10</sup> reminiscent of history book photographs, the faces of Eddington, Cottingham, and others do not reappear. When readers do get to see them, they are shown in impressionistic glimpses of their figures (Simões & Sousa, 2019: 144-145; 2023: 152-153, 166), or in the form of first-person point of view (POV) shots (Simões & Sousa, 2019: 143; 2023: 151). The representations of these characters neither differ from nor overshadow the portrayals of other characters in the story, like boat passengers or local inhabitants at the sites visited, thereby maintaining equal representation among a wide network of actors and agencies. Such an approach marks a notable departure from what readers might expect in books about famous historical figures and events, especially those featuring eminent personalities like Einstein (Gates Jr & Pelletier, 2019; Kennefick, 2019; Stanley, 2019).

This is the reason behind the deliberate omission of Einstein's face in the graphic novel, in which readers are presented with only his silhouettes and extreme close-ups, climaxing in a full-page illustration that prominently displays his back (Simões & Sousa, 2019: 175,



**Fig. 2** a The correct location of the installation. b Installation (double page spread)

187, 188; 2023: 191, 203, 204) (Fig. 3a). Einstein's image has become so ubiquitous to lose its impact, to the point of becoming commonplace. By denying readers access to Einstein's

iconic visage, the graphic novel offers them a fresh perspective on his character, moving away from the glorified depictions often seen in science communication, where he is frequently elevated to a near God-like status. Moreover, this “un-portrayal” aligns with a time when “Albert was not yet Einstein” (Simões, 2019: 12). That is, when Eddington’s letters were penned, Einstein’s theory of general relativity was still undergoing scrutiny and few, among whom stood Eddington, understood it. In fact, Einstein’s rise to public prominence followed the expeditions’ results presented at the joint meeting of the Royal Society of London and the Royal Astronomical Society on 6 November 1919. While typically portraying someone’s face serves to humanize them, for figures as monumental as Einstein, depicting his face can have a dehumanizing effect, associating him to the icon rather than the human being behind it.

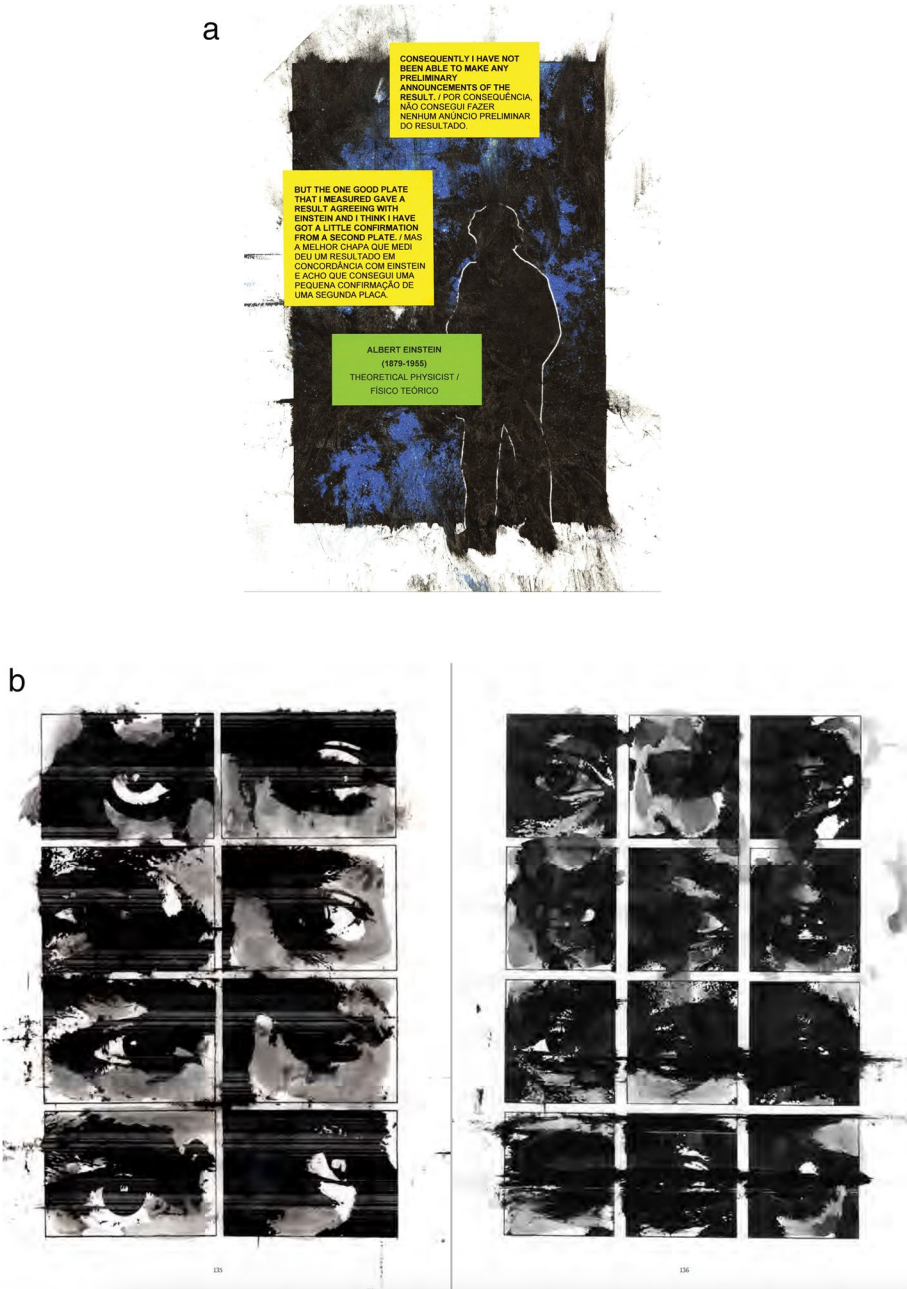
The graphic novel follows the same strategy regarding Eddington (Simões & Sousa, 2019: 170, 174, 190, 191; 2023: 186, 190, 206, 207), even though he is not as widely recognized by the public as Einstein. For example, in the last four pages (Simões & Sousa, 2019: 189-192; 2023: 205-208), in which Eddington is depicted returning to his house in England, only his silhouette or back is visible to the reader. This visual rendition is accompanied by excerpts from the last letter written to the vice-director of the Observatory of Lisbon, thanking him for his assistance and sending paper enlargements of three photographs of the solar eclipse observations, including the most famous one, showing an impressive prominence.

Having detailed the approach to portraying Einstein and Eddington, our attention now turns to the representation of the laborers from the Sundry cocoa plantation, as mentioned in Eddington’s letters (Fig. 3b). These laborers played a crucial role in transporting the scientific equipment to the site, carrying it over areas where there were no railroad tracks, building a pedestal for the equipment, and generally supporting the team whenever necessary. Since there are no visual records of these laborers on the plantation, both male and female, it was opted to bring attention to them by illustrating their (imagined) eyes (Simões & Sousa, 2019: 133; 2023: 135-137). This concept was further developed in the second edition, with six additional pages dedicated to these anonymous workers: in the first two, their eyes are represented in a crescendo from the original page, depicting eight eyes to 12 and 32; in the next two, a male and a female worker are depicted carrying boxes of material (Simões & Sousa, 2023: 138, 139); the final two pages depict their faces in close-up, from a low-angle perspective, as they gaze upwards at the sky, a gesture that invites various interpretations (Simões & Sousa, 2023: 140, 141). These pages are unique in that they are entirely black and white, with no post-its, setting them apart from the rest of the pages and, especially, from the colorful aerial view of the plantation Sundry that precedes them. Moreover, the laborers’ significance is reinforced by a page after the eyes sequence, which displays the train rails they used to transport the equipment (Simões & Sousa, 2019: 134, 142). Collectively, these pages highlight the essential yet often overlooked role of workers in ensuring the expedition’s success.

In short, a scientific hero, Einstein, whose face is widely recognized, is deliberately depicted as faceless, while the anonymous plantation laborers were rendered visible, boldly confronting the reader with their eyes. This kind of inversion extends beyond a traditional hero-centric visual representation of historical events, aiming to express the multifaceted nature of reality in more inventive, unexpected ways.

## 4.2 Visualizing Other Invisible Actors: Colonial Authorities and Elite People

Eddington mentions colonial authorities in letters to his mother written upon arrival to the island and following departure from Príncipe. In the first letter, from 29 April 1919, Eddington



**Fig. 3** a Einstein's back and b workers' eyes (two pages)

refers to Jerónimo Carneiro, the owner of the Sundry plantation, where the expeditioners were accommodated, and where the observations took place, to the manager of the Colonial Agricultural Society, to the governor, to the judge, to the “curador,” who was responsible for

imported labor, to the treasurer, to Carneiro's clerk, and finally to Atalaia, Carneiro's Sundry administrator.

At the time the 2019 edition was published, photographs of these individuals had not been discovered, whereas now a picture of Carneiro was found.<sup>11</sup> To address the lack of photographs in the graphic novel, an inventive approach was used, portraying the characters as different bird species found on Príncipe Island, known for its biodiversity; Atalaia, however, who had a special connection with Eddington marked by frequent conversations in cursory French, was illustrated as a frog (Simões & Sousa, 2019: 113-117; 2023: 113-117). Within the color-coded post-it scheme, the green post-its were assigned to show the scientific names of different animal species. This associative approach was not meant to draw direct parallels between humans and animals, but rather to highlight their coexistence and the complex dynamics in a colonial context.

In the same letter, Eddington refers to Mr. Lewis and Mr. Wright, who were two Sierra Leonean black British technicians employed at the local cable station, and who occasionally served as interpreters. Eddington also notes the absence of "ladies" among the elite on the plantation. These brief mentions of race and gender are found on pages 117 and 118 of both editions, painted in warm shades of red and yellow, contrasting with the birds on the previous pages that appear in cooler shades of green and blue. On page 117, Lewis and Wright are depicted in the same impressionistic style as mentioned earlier, with details of their backs and imagined faces. On page 118, a series of four panels depicting tall grass waving in the wind, with no words associated, conveyed a sense of vacatness, and as such stood for the absence of elite females.

In his last letter to his mother from 21 June 1919, Eddington provided a meticulous account of the eclipse's totality, the climax of the expedition, making it the sole surviving document where Eddington names everyone who witnessed the totality. Beyond the two expeditioners, seven colonial staff members observed the eclipse, some possibly helping in important ways, as was probably the case of Wright (Simões, 2022a: 594). In the graphic novel, we opted to depict them as full-body silhouettes that fill a large panel, along with those of Cottingham and Eddington, as if they were posing for a group photo that never happened (Simões & Sousa, 2019: 167; 2023: 179). The use of silhouettes acknowledges the lack of actual images depicting such an important moment, yet ensures their presence is both seen and felt, thereby emphasizing their agency and the entanglement of science, politics, and empire in the totality observation, typically deemed a purely scientific endeavor.

## 5 Singularizing the Total Solar Eclipse

### 5.1 Stars, Spiders, and a Turtle

The climax of Eddington's and Cottingham's journey was the observation of totality, which the graphic novel vividly portrays over the course of four pages (Simões & Sousa, 2019: 158-161, 2023: 170-173). These stood out, in the original edition, for their "silent" nature, constituting the only complete sequence that relied purely on visual narration without text, effectively emphasizing crucial moments by removing elements instead of adding them. In the second edition, we decided to add another two additional silent sequences, previously mentioned: four pages that present selected views of a 3D reconstruction of the observational setup (Simões & Sousa, 2023: 181-184), and another focusing on the unnamed workers of the Sundry plantation (Simões & Sousa, 2023: 135-141). Across the graphic novel, these "silent"

sequences disrupt the established narrative flow, creating a distinct atmosphere, and weave together the eclipse, the observation, and the laborers from the Sundy plantation. Thus, they embody Thierry Groensteen's concept of "tressage" presented in *The System of Comics*, meaning "weaving" or "braiding," a comic technique that emphasizes complex storytelling and the interplay between various elements during the entire length of a comic, transcending linear panel progression (Groensteen, 2009: 145–149, 156–158) (Fig. 4).

The work's artistic decisions not only underscore key scientific moments and figures but also uncover various dimensions of knowledge in unexpected, often overlooked ways, making them ideal topics for engaging discussions in a classroom environment.

Let us examine the eclipse sequence in more detail. The third page of the eclipse sequence consists of a series of panels depicting the moon passing in front of the sun, while the fourth and last page features a single panel showing the eclipse totality in great prominence. However, the first two pages (Simões & Sousa, 2019:158, 159; 2023: 170, 171) are arguably the most surprising: in the first, the reader is shown a spider crawling on the ground, followed, on the next page, by a panel depicting several spiders suspended in the air (upper panel), juxtaposed against another panel depicting stars (below). The motif of the spider emerged during the project's initial stages, while Ana Matilde Sousa was creating illustrations for a set of postcards to be distributed at the opening of the exhibition *E3. Einstein, Eddington, and the Eclipse*, curated by Ana Simões in 2019.<sup>12</sup> In one of these illustrations, some spiders were depicted on a blue background to evoke tropical biodiversity; however, upon closer inspection, we realized that the depicted spiders could be misconstrued as stars, in the sky, such as those behind the sun which the expeditioners photographed. This ambivalence between spiders and stars, discovered by chance, was intentionally incorporated into the final work. The spider motif symbolically bridges earth

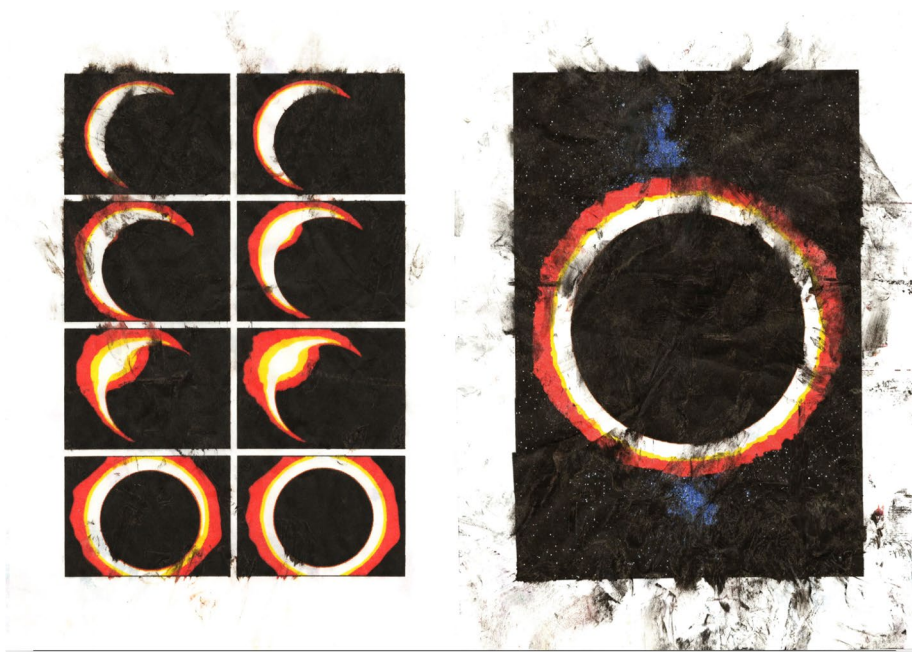


Fig. 4 Eclipse

and sky, reflecting spiders' movement on the ground and suspension in webs, as if floating in air; moreover, the spiders' web also serves as a powerful visual metaphor for the complex web of human and non-human actors involved in the expedition, adding layers of poetic and symbolic meaning, and foreshadowing the spiders' significant role in the eclipse sequence.

In an interesting observation, the Portuguese comic scholar and critic Pedro Moura noted that in Hergé's classic album *The Shooting Star* (1942), there is a scene where Tintin, while peering through a telescope, becomes frightened by a large spider perched atop the lens (which dramatically increases its size). He immediately associated the eclipse sequence with this iconic moment in comics history. This episode illustrates the importance in comics, as in other arts, of being attentive to unexpected, organic developments during the creative process, for such spontaneous elements and connections can enrich the narrative in unforeseen ways. However, in our view, science communication comics often lack room for ambiguity, interpretation, and experimentation, leaning too heavily on the medium's perceived innocuousness as a tool for transmitting information.

Another example of this openness to creative interpretations can be seen in the illustration on the cover of the book, and on page 109 of both editions. This illustration depicts a turtle swimming underwater, viewed from below, which temporarily blocks the light shining from the sky above. As with the spiders, the idea was to convey the rich biodiversity of the São Tomé e Príncipe archipelago, which is a breeding and feeding ground for five of the seven species of sea turtles worldwide. Like spiders mimicking stars, the turtle also serves as a metaphor for the eclipse, with its movement through the water resembling that of the moon passing in front of the sun. This powerful image was selected for the cover as it encompasses the essence of the book's central theme—the eclipse—and the expedition's destination—the island of Príncipe—albeit in an indirect and unconventional manner meant to arise the readers' curiosity and imagination (Fig. 5).

## 5.2 The Materiality of Eclipse Photographs

Besides its direct depictions, the eclipse also features in the graphic novel through photos taken by Eddington and his team, which were instrumental in proving Einstein's theory of relativity. As previously mentioned, Eddington's final letter to his mother included a detailed account of the observation of the eclipse's totality and a preliminary assessment of the results, mentioning the 16 photographs taken, hindered by clouds obscuring the stars they needed to observe. Despite this, the photographs captured a spectacular solar prominence. To depict the photographs, two pages with a kind of metonymic reinforcement were employed, in which each comic panel corresponds to a rectangular photograph (Simões & Sousa, 2019:171, 172; 2023:187, 188).

On the first page, there are 16 panels representing the 16 photographs taken, arranged in four rows of four panels. The first three rows display already developed photographs, while the last row shows four completely black panels. These four panels illustrate what Eddington mentions in his letter, namely, that four photographs had not yet been developed. Additionally, the panels are intentionally angled with a slight tilt, not only to create a more dynamic composition, but also to emphasize their object-like nature, making them appear less like "proper" comic panels and more like a collection of photographs lined up on a table. The second page offers a closer look at some photographs introduced on the previous page, emphasizing the stars, seen as points of light, that Eddington needed for his calculations that would confirm Einstein's light bending prediction. This page arranges



**Fig. 5** Eclipsed sun turned into a strawberry

six panels in three rows of two, upright rather than tilted, to draw the reader or student's attention to these crucial scientific results. Through this arrangement, the pages play with a more abstract compositional style, which harnesses the potential of comics as a medium to express concepts in a way that only comics can accomplish.

## 6 Bringing Back Into the Picture the British Expeditioners at Sobral

In his final letter home during the return journey, Eddington referred to the long-awaited news sent by Dyson announcing that the Brazilian team had managed to obtain clear images of the eclipse. This reference to Dyson in Eddington's communication provided a clue to integrate the other British team into the graphic novel, partially restoring the balance vis-à-vis the essay's symmetrical treatment of both teams. To visualize Dyson and his colleagues in the graphic novel, one of the many photographs available of Sobral's British team, taken together with the Brazilian team led by Henrique Morize, the director of the National Observatory of Rio de Janeiro, was used (Simões & Sousa, 2019:181, 182; 2023: 197, 198; Simões, 2022b). These pages were followed by a full-page panel showcasing a totality photograph captured by the American team of magnetic observers, who joined the British and Brazilian teams of astronomers (Simões & Sousa, 2019:183; 2023: 199); they also witnessed the eclipse at Sobral and detailed their experience in an amazing photographic album (Crispino & de Lima, 2018).

Finally, to make the transition from Sobral back to Eddington, the graphic novel creatively employed a recurring detail from his letters. On several occasions, Eddington avowed his fondness for English strawberries, considering them better than tropical fruits,



and he even shared with his mother his hope that he would return to England in time for the strawberry season. Taking advantage of the fact that a strawberry and the sun have a similar shape, a page with two panels was created, in which the upper panel shows the eclipsed sun from the previous page, while the lower panel presents a strawberry mirroring the sun's circular shape (Simões & Sousa, 2019:184; 2023: 200). This juxtaposition suggests that the eclipsed sun has been transformed into a strawberry, re-immersing the reader into Eddington's point of view. This artistic choice effectively demonstrates how personal feelings and memories often color our perception of the world around us.

## 7 Conclusion

This paper's examination of *Einstein, Eddington, and the Eclipse: Travel Impressions* highlights the powerful and transformative potential of integrating arts into science research and education. By interweaving a history of science essay with a graphic novel and an analytical paper, it presents a cohesive, transdisciplinary approach, that is both innovative in its content and structure, to a pivotal historical event—the 1919 British expeditions to Príncipe and Sobral to observe the total solar eclipse—which played a key role in validating Einstein's theory of general relativity. It should be noted that, from the outset, the book was intentionally designed to maintain a fine balance, often difficult to accomplish, in which the essay and graphic novel mutually enhance and complement each other, without either being merely an illustrative extension of the other.

One of the key aspects of this project is the collaboration of a historian of science, Ana Simões, and an artist, Ana Matilde Sousa. This partnership has resulted in the graphic novel within the book that departs from typical science communication comics by embracing an experimental, “art comics,” style, and employing complex, richly woven storytelling methods. By selecting several key moments from the graphic novel for in-depth analysis (though many more would merit attention), a firsthand, insider account into the creative process, themes, and decision-making involved in the graphic novel was provided in this paper. This method not only challenges the misconception that comics are (or should be) just a means to simplify scientific topics, but it also aids readers in appreciating the intricacies and layers of the work. Furthermore, it provides educators with a versatile “skeleton key,” in the literary sense, ideal for science undergraduate students, that encourages critical analysis of the book's scientific and historical content, thereby enriching educational experiences, improving scientific and general literacy, and promoting critical thinking and a more holistic, cross-disciplinary learning. Finally, it is hoped that this paper acts as a catalyst for both artists aiming to integrate scientific themes into their artwork and science educators planning to develop comics or other visual arts projects, thereby contributing to the emergence of novel educational resources that blend scientific rigor with artistic expression.

In conclusion, *Einstein, Eddington, and the Eclipse: Travel Impressions*, with its combination of an essay and a comic into a single volume, both innovative in their individual formats and in their synergistic combination, represents a significant contribution to the field of science education, aligning with the principles of the STEAM framework. The book, and now this accompanying paper, both products of a collaborative effort, actively seek to shift and broaden the narrative focus by emphasizing the myriad factors that influenced the expeditioners' travels and the groundbreaking scientific events in which they were involved. Based on our classroom experiences, which are too extensive to be covered in this paper and would warrant a separate discussion—especially considering future student

engagement with this paper—we have observed that this method motivates students to deepen their understanding of the scientific enterprise and its connections to science, religion, and society, including its global scope, geopolitical imbalances, and colonial contexts. It also reveals a diverse array of actors and networks, from major scientists to local experts and to anonymous people, all of whom are integral to the successes of the scientific enterprise. Many of these participants, previously eclipsed in canonical narratives, are now emphasized and brought into clearer view.

## 8 Notes

1. There is a vast literature on the topic, starting from the now classic (Cooter & Pumphrey, 1994). See for example Nieto-Galan (2016).
2. While the perception of quality can be subjective, *Einstein, Eddington, and the Eclipse: Travel Impressions* has notably received several highly favorable reviews from both the artistic and scientific communities, stressing its invocative aspects and singularity in the fields, reflecting its well-received impact. See for example Renn (2021), Ryan C. (27 April 2021) and Kent (2022).
3. For the astronomical predictions, see for example Hentschel (1997) for the gravitational redshift; for the light bending prediction and the explanation of the anomaly of Mercury's perihelion see Earman and Glymour (1980), but particularly Crelinsten (2006), which offers a detailed analysis of attempts prior to 1919 and emphasizes the leading role of American astronomers, and also Roseveare (1982) for the Mercury's anomaly.
4. There were various attempts in 1911, 1912, and 1918 (see Crelinsten, 2006; Simões and Soares, submitted).
5. There is a vast body of literature on this topic. A few highlights include the following: Earman and Glymour (1980), Kennefick (2019), Stanley (2019).
6. Accounts of the two expeditions can also be found in Mawhinney (2018), highlighting the central role of geography, and the popularization of science book (Gates and Pelletier, 2019), using a somewhat hagiographic posture, as one can surmise from the title and sub-title: addressing the “daring” expeditions in their relationship with Einstein's heroic status and groundbreaking results. The comparative exercise also wanted to go a step further from accounts either focusing on the Sobral's expedition, for which there is immense literature or alternatively on the Príncipe's expeditions (see for example: Moreira & Videira, 1995; Videira, 2012; Crispino and Lima, 2016; Mota, Crawford and Simões, 2009).
7. TCL: EDDN A4/2—Trinity College Archives, Eddington Correspondence. Letters from Eddington to mother Sarah Ann Eddington dated 11, 15–16, 27 March 1919; 6, 13, 20, 29 April 1919; 21 June–2 July 1919 and to sister Winifred Eddington dated 5 May 1919.
8. Arquivo Histórico dos Museus da Universidade de Lisboa, Observatório Astronómico de Lisboa, Universidade de Lisboa. Correspondence from Arthur Stanley Eddington to the Direction of OAL, PT/MUL/OAL/C/240, including letters from 11 November 1918, 21 December 1918, 14 January 1919, 8 February 1919, 26 February 1919, 25 March 1919, 4 May 1919, and 3 August 1919. Besides the first and last letters, in the graphic novel we also used letter from 4 May 1919.
9. See map depicting the trajectories of the two expeditioner teams on the back leaf of the book cover (Simões & Sousa, 2019, 2023).

10. Cottingham's portrait figures in one of the modified pages in the second edition, following his previously incorrect identification.
11. In the 2023 edition, page 122 features a picture of Carneiro, thanks to Hugo Soares' recent findings.
12. The exhibition was held at the Museum of Natural History and Science (MUHNAC) in Lisbon from 16 May to 8 September 2019 as part of the centennial celebrations of the 29 May 1919 total solar eclipse. The exhibition then moved to the Nova School of Science and Technology (FCT), of the NOVA University of Lisbon, from 16 September to 23 October 2019, and finally to Faculty of Sciences of the University of Lisbon (FCUL), where it was launched on 29 December 2019, and where it stayed until 12 April 2021, due to the pandemics. It was organized in five modules: "The three main characters" (Einstein, Eddington and the Eclipse); "Eclipse chasers"; "The journey" (tryptic including the part of the travel common to all expeditioners, Sobral, and Príncipe); the "Final outcome"; and lastly "The answer from Lisbon."

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## Declarations

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

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## References

- Biggs, M., & Karlsson, H. (Eds.). (2012). *The Routledge companion to research in the arts*. Routledge.
- Brush, S. G. (1974). Should the history of science be rated X? *Science, New Series*, 183(4130), 1164–1172.
- Candy, L., & Edmonds, E. (2017). Practice-based research in the creative arts: Foundations and futures from the front line. *Leonardo*, 51(1), 63. [https://doi.org/10.1162/LEON\\_a\\_01471](https://doi.org/10.1162/LEON_a_01471)

- Cooter, R., & Pumphrey, S. (1994). Separate spheres and public places: Reflections on the history of science popularization and science in popular culture. *History of Science*, 32, 237–267.
- Cottingham, E. T. (1919). The Observatory, 42, 291–292.
- Crelinsten, J. (2006). *Einstein's jury. The race to test relativity*. Princeton University Press.
- Crispino, L. C. B., & de Lima, M. C. (2016). Amazonia introduced to general relativity: The May 29, 1919 solar eclipse from a north-Brazilian point of view. *Physics in Perspective*, 18(4), 379–394.
- Crispino, L. C. B., & de Lima, M. C. (2018). Expedição norte-americana e iconografia inédita de Sobral em 1919. *Revista Brasileira do Ensino de Física*, 40(1), e1601.
- Doxiadis, A., Papadimitriou, C. H., Papadatos, A., & Donna, A. D. (2009). *Logicomix: An epic search for truth*. Bloomsbury.
- Dyson, F. W., Eddington, A. S., & Davidson, C. (1920). A determination of the deflection of light by the sun's gravitational field, from observations made at the total solar eclipse of May 29, 1919. *Royal Society of London, Philosophical Transactions*, A220, 291–333.
- Earman, J., & Glymour, C. (1980). Relativity and eclipses: The British expeditions of 1919 and their predecessors. *Historical Studies in the Physical Sciences*, 11, 49–85.
- Farinelli, M. (2018). The potential of comics in science communication. *JCOM*, 17(1), 1–17.
- Field, M., Lee, R., & Field, M. L. (1994). Assessing interdisciplinary learning. *New Directions in Teaching and Learning*, 58, 69–84.
- Gamito-Marques, D. (2020). In praise of a historical storytelling approach in science education. *Isis*, 111(3), 582–587.
- Gates, S. J., Jr., & Pelletier, C. (2019). *Proving Einstein right: The daring expeditions that changed how we look at the universe*. Public Affairs/Hachette Book Group.
- Gooday, G., Lynch, J. M., Wilson, K. G., & Barsky, C. K. (2008). Does science education need the history of science? *Isis*, 99, 322–330.
- Groensteen, T. (2009). *The system of comics*. University Press of Mississippi.
- Hentschel, K. (1997). *The Einstein Tower. An intertexture of dynamic construction, relativity theory, and astronomy*. Stanford University Press.
- Hickman, R. D. (2008). *Research in art and design education: Issues and exemplars*. Intellect books.
- Kavaloski, V. (1979). Interdisciplinary education and humanistic aspiration: A critical reflection. In J. Kockelmanns (Ed.), *Interdisciplinarity and higher education*.
- Kennefick, D. (2019). *No shadow of a doubt. The 1919 eclipse that confirmed Einstein's theory of relativity*. Princeton University Press.
- Kent, D. (2022). Einstein, Eddington, e o/and the Eclipse: Impressões de Viagem/Travel Impressions. *British Journal for the History of Mathematics*, 37(2), 162–163.
- Kuchinskaya, O. (2012). Twice invisible. Formal representations of radiation danger. *Social Studies of Science*, 43(1), 78–96.
- Kuchinskaya, O. (2014). *The politics of invisibility. Public knowledge about radiation health effects after Chernobyl*. MIT Press.
- Latas, J., Pape, D., & Simões, A. (2020). Where exactly did A.S. Eddington observe the total solar eclipse of 29 May 1919. *JAHH. Journal of Astronomical History and Heritage*, 23(3), 614–627.
- Madden, L., Blatt, C., Ammentorp, L., Heddy, E., Kneis, D., & Stanton, N. (2022). From science in the art gallery to art in the science classroom. *Journal of College Science Teaching*, 51(6) <https://www.nsta.org/journal-college-science-teaching/journal-college-science-teaching-julyaugust-2022/science-art>
- Mawhinney, R. (2018). Astronomical field work and the spaces of relativity: The historical geographies of the 1919 British eclipse expeditions to Príncipe and Brazil. *Historical geography*, 46, 203–238.
- McNiff S., ed. (2013). *Art as research: Opportunities and challenges*. Intellect.
- Moreira, I. C., & Videira, A. A. P. (Eds.). (1995). *Einstein e o Brasil*. UFRJ.
- Mota, E., Crawford, P., & Simões, A. (2009). Einstein in Portugal: Eddington's expedition to Príncipe and the reactions of Portuguese astronomers (1917–1925). *British Journal for the History of Science*, 42, 245–273.
- Moura, P. (2013). *Art comics*. LerBD <http://lerbd.blogspot.com/2013/10/art-comics.html>
- Moura P. (2020). CFP: The Ilan Manouach critical reader. <https://www.comicgesellschaft.de/2020/09/18/cfp-the-ilan-manouach-critical-reader/>
- Nieto-Galan, A. (2016). *Science in the public sphere. A history of lay knowledge and expertise*. Routledge.
- Padua, S. (2015). *The thrilling adventures of lovelace and babbage: The (mostly) true story of the first computer*. Pantheon.
- Paranjpe, D. (2022). *Why include an interdisciplinary approach to science education at the school and college level*. Azim Premji University <https://azimpremjijuniversity.edu.in/news/2022/the-power-of-infusion-of-science-education-and-research>
- Rader, K. (2020). Introduction: The changing pedagogical landscapes of history of science and the “two cultures”. *Isis*, 111, 568–587.

- Renn, J. (2021). The global adventure of science *Centaurus*, 63(3), 616–617.
- Roseveare, N. T. (1982). *Mercury's perihelion. From Le Verrier to Einstein*. Clarendon Press.
- Ryan C. (2021) Four color apocalypse review “Eurocomics spotlight: Einstein, Eddington and the Eclipse” <https://fourcolorapocalypse.wordpress.com/2021/04/27/eurocomics-spotlight-einstein-eddington-and-the-eclipse/>
- Simões, A. (2019). *Einstein, Eddington e o Eclipse. Um encontro improvável, duas expedições memoráveis*. MUHNAC <https://zenodo.org/record/816368>
- Simões, A. (2022a). In the shadow of the 1919 total solar eclipse: The two British expeditions and the politics of invisibility. *Berichte zur Wissenschaftsgeschichte*, 45, 581–601.
- Simões A. (2022b) O eclipse solar total de 1919. Assimetrias geopolíticas e eclipses narrativos *Sigila* 50, 131-140.
- Simões A. and Soares H. (n.d.). ‘The many faces of prediction. Changing aims of the astronomical expeditions organized during the 1910s to test the deflection of light.’
- Simões, A., & Sousa, A. M. (2019). *Einstein, Eddington and the Eclipse. Travel impressions* (bilingual ed.). Chili com Carne.
- Simões A. and Sousa A.M. (2023) *Einstein, Eddington and the Eclipse. Travel impressions*. <https://zenodo.org/record/7879079>.
- Smith, H., & Dean, R. (2009). *Practice-led research, research-led practice in the creative arts*. Edinburgh University Press. <https://doi.org/10.1515/9780748636303>
- Stanley, M. (2003). ‘An expedition to heal the wounds of war’. The 1919 eclipse and Eddington as Quaker adventurer. *ISIS*, 93, 57–89.
- Stanley, M. (2007). *Practical mystic: Religion, science and A.S. Eddington*. Chicago University Press.
- Stanley, M. (2019). *Einstein war*. Dutton.
- Tatalović, M. (2022). The problem with science comics: Uncritical images and ideology of research. *EuroScientist journal* <https://www.euroscientist.com/the-problem-with-science-comics-uncritical-images-and-ideology-of-research/>
- UNESCO. (2005). *Education for all: Literacy for life; EFA global monitoring report, 2006*. UNESCO <https://unesdoc.unesco.org/ark:/48223/pf0000141639>
- UNESCO. (2006). *Synergies between formal and non-formal education: an overview of good practices*. UNESCO <https://unesdoc.unesco.org/ark:/48223/pf0000146092>.
- UNESCO. (2014a). *UNESCO Roadmap for implementing the global action programme on education for sustainable development*. UNESCO <https://sustainabledevelopment.un.org/content/documents/1674unescoroadmap.pdf>
- UNESCO. (2014b). *Global citizenship education: Preparing learners for the challenges of the 21st century*. UNESCO <https://unesdoc.unesco.org/ark:/48223/pf0000227729>
- UNESCO. (2020). *Education for sustainable development: A roadmap*. UNESCO <https://unesdoc.unesco.org/ark:/48223/pf0000374802>
- Videira, A. A. P. (Ed.). (2012). *Henrique Morize e a causa da ciência pura no Brasil*. Zit Editora.
- Villani, C., & Baudoin, E. (2015). *Les reveurs lunaires: quatre genies qui ont changé l’histoire*. Gallimard BD.

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