Visualizing complex data for citizen education: a pedagogical workshop

Visualização de dados complexos para uma formação cidadã: um workshop pedagógico

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data visualization, critical literacy, science communication, citizen education

This article presents the *Amplia Saúde* Workshop, developed to engage non-specialist audiences with complex data visualizations on social and health issues originally created for researchers and health professionals. We asked whether such visualizations, when adapted for educational settings, could foster collective discussion and support critical data literacy. The workshop combined the scientific communication strategy with design thinking and was grounded in Freire-inspired critical pedagogy. Implemented with high school students in a public school in Rio de Janeiro, it used interactive visualizations from the *Amplia Saúde* platform together with activity booklets and teacher support materials. The results showed that students' interest increased when data were contextualized within their own realities, that platform interaction required guided mediation to avoid misinterpretation, and that pedagogical materials were central in scaffolding comprehension. These findings indicate that complex visualizations, when critically mediated, can promote collective discussion, foster critical data literacy, and inform broader initiatives for lay adult audiences.

visualização de dados, letramento crítico, comunicação científica, formação cidadã

Este artigo apresenta o Workshop Amplia Saúde, desenvolvido para envolver públicos não especialistas com visualizações de dados complexos sobre questões sociais e de saúde, originalmente criadas para pesquisadores e profissionais da área. Buscou-se investigar se tais visualizações, quando adaptadas para contextos educacionais, poderiam fomentar a discussão coletiva e apoiar o letramento crítico em dados. O workshop combinou uma estratégia de comunicação científica com design thinking e fundamentou-se na pedagogia crítica inspirada em Paulo Freire. Implementado com estudantes do ensino médio de uma escola pública no Rio de Janeiro, o workshop utilizou visualizações interativas da plataforma Amplia Saúde, acompanhadas de cadernos de atividades e materiais de apoio para professores. Os resultados mostraram que o interesse dos estudantes aumentou quando os dados foram contextualizados em suas próprias realidades; que a interação com a plataforma exigiu mediação orientada para evitar interpretações equivocadas; e que os materiais pedagógicos foram fundamentais para apoiar a compreensão. Esses achados indicam que visualizações complexas, quando mediadas de forma crítica, podem promover a discussão coletiva, estimular o letramento crítico em dados e contribuir para iniciativas mais amplas voltadas a públicos adultos leigos.

1 Introduction

Data visualization increasingly permeates multiple domains, ranging from public policy and health to economics and everyday life, supporting decision-making processes and mediating interpretation. Nevertheless, the impact of data visualization in society remains limited by challenges related to data literacy production processes, as well as by the capacity of visualizations to foster critical discussion and reflection. From this standpoint, our study initiates an inquiry into the potential of data visualization to advance data literacy and, at the same time, to create opportunities for dialogue and critical reflection by lay audiences from the employment of data visualization.

For this endeavor, we designed a pedagogical workshop built around the *Amplia Saúde* platform (ampliasaude.org) – an online environment that aggregates and visualizes data on maternal and newborn health and air pollution across Brazilian municipalities, and related socio-economic indicators. Although the platform primarily serves researchers and public health managers, the workshop adapts its interactive visualizations for high school students, with the goal of exploring patterns in the visualizations, formulating hypotheses, and discussing possible evidence-based interventions. In this way, the workshop seeks to foster literacy and stimulate the development of critical thinking in the classroom.

Building on this approach, we formulated the following research question: to what extent can the oriented use of complex data visualizations about social and health issues in the educational context promote collective discussion and support the development of adolescents' critical data literacy, while also offering insights that could be applicable to data literacy initiatives aimed at lay adult audiences?

Starting from this research question, the development of the workshop considered the use of the scientific communication strategy (Besley & Dudo, 2022) combined with the stages of design thinking and its iterative and ideation processes (Cross, 1982; Brown, 2010). These approaches informed the conception of our strategic objectives in relation to the specific student audience, as well as the creation of didactic materials and teaching support resources. Above all, the theoretical foundations on literacy – both creative and critical – in data visualization (D'Ignazio & Bhargava, 2018; Freire, 1987) provided the basis for the pedagogical approaches and the proposals for collective discussion conducted during the workshop. Because the study involved young people in a school environment, all procedures, materials, and classroom activities were submitted to and approved by the Research Ethics Committee (CEP) of UFRJ.

We present in this article the workshop's design stages and the results obtained from six high-school classes in a public school in the state of Rio de Janeiro. The project demonstrates how social and health data visualizations can be adapted to classroom practice in ways that foster engagement with data and prompt collective critical reflection through dialogue, while also suggesting approaches that may be transferable to initiatives targeting lay adult audiences.

The article is organized as follows: first, a section on related work addressing the use of data visualization as a pedagogical tool; next, the methodological framework; followed by the description of the materials and the creation of the pedagogical workshop; then a report on the classroom implementation; and, finally, the discussion and conclusion.

2 Related work

In recent years, data visualization has become a central pedagogical tool across educational levels and for non-experts alike. Its use extends beyond the mere representation of information, supporting exploration, inquiry, and the construction of meaning. This section draws on two areas of educational research: (a) Pedagogical Approaches in Data Visualization Education and (b) Critical Data Literacy and Paulo Freire's Influence.

2.1 Pedagogical approaches in data visualization education

Within primary and secondary education, pedagogical strategies that emphasize student engagement and agency have shown promise, yet still reveal gaps requiring further development. Research by Grammel et al. (2010) highlighted significant challenges novices face when translating questions into data attributes, designing visual layouts, and interpreting visual representations. To address this, studies have explored hands-on and creative methods, such as Kejstová et al.'s (2023) use of playful elements like LEGO bricks and tokens to encourage students to construct their own visualizations. However, they also identified a need for didactic methods to assist students in interpreting less familiar visualizations.

Similarly, Naps et al. (2003) argue that the impact of visualization in enhancing student learning is limited due to unmet instructor needs, particularly regarding the time and effort required to learn, adapt, and integrate educational tools. Chevalier et al. (2018) propose that visualization literacy should encompass the ability to create visualizations, foster critical thinking, and integrate related literacies such as data and information literacy. Taken together, these studies highlight the importance of data visualization design for fostering literacy and critical thinking. Our approach builds on these goals by emphasizing interaction with complex visualizations of relevant real-world data.

To further support teachers, Ahn, Nguyen, and Campos (2021) found that training educators in data interpretation alone is not sufficient. This body of research suggests that while activities fostering visual design literacy and technical skills are valuable, there is a growing need to provide both students and teachers with agency and instructional support to move toward deeper, more meaningful engagement with data visualization literacy and assessments (Börner et al., 2019; Bach et al., 2023). At this point, we stress the necessity of producing instructional support for teachers who will apply the workshop with students.

2.2 Critical data literacy and Paulo Freire's influence

A growing body of research underscores the importance of critical perspectives in data literacy, explicitly drawing from Paulo Freire's pedagogy of autonomy, emancipation, and dialogic education. Freire's framework, as adapted for data literacy, emphasizes that true literacy transcends acquiring technical skills to encompass the capacity to question, interpret, and transform reality through active engagement with data (Freire, 1987; Tygel & Kirsch, 2016; D'Ignazio, 2022; Dangol & Dasgupta, 2023).

Visualization has been identified as a key tool in this process, with studies suggesting that data visualizations influence and transform educational practices (Ratner, 2025) and that critical data education is essential to help students understand and resist the social, political, and ethical impacts of datafication (Pangrazio & Selwyn, 2021). D'Ignazio (2022) explicitly grounds her concept of "creative data literacy" in Freire's notion of popular education, arguing that empowerment through data involves not only analytical skill development but also emancipation within the literacy process.The convergence of these pedagogical and critical aims is increasingly recognized in the literature. For example, Wilkerson et al. (2025) note that a growing number of teaching materials are encouraging students to discuss the complex mathematical, contextual, and social aspects of data visualizations, positioning students as "historical actors" who can repurpose data to design better futures.

Despite this convergence, research on how real-world, socially charged data visualizations can be used in classroom settings for these dual purposes remains scarce. The present study addresses this gap by engaging Brazilian high school students with maternal and neonatal health data through the ampliasaude.org platform. This approach fosters both data visualization skills and critical engagement with complex public health and social issues, aligning closely with Freirean educational principles.

3 Methodological framework

We designed a pedagogical workshop with the understanding that teaching data literacy early helps equip citizens to interpret the complex visual information that increasingly surrounds them.

To bring these values into the classroom through a workshop, we adopted science communication processes. From the outset, we assumed that non-specialist audiences are not passive recipients but active participants who contribute to the cultural, social, and political contextualization of science communication (Bucchi & Trench, 2008). For the development of the design stages, the methodological foundation was the strategic science communication approach proposed by Besley and Dudo (2022), who emphasize the importance of defining communication objectives and aligning formats and language with audience needs.

Guided by this synthesis, our communication objectives for the workshop were articulated as concrete learning outcomes for the target audience:

- Recognize the value of visualization for interpreting large-scale societal data.
- Explain that data are a snapshot of reality, subject to multiple interferences during collection and subsequent processes, and therefore non-neutral;
- Use an interactive visualization tool to analyze indicators and derive evidence-based insights.

These objectives not only make the workshop evaluable but also align it with our broader dialogic approach. Building on Börner et al. (2019), and in order to provide teachers and students with adequate instructional support, we decided to produce two different types of pedagogical materials, one tailored for each group.

From these premises, we developed the following hypotheses regarding students' understanding and analysis of the data:

- Students' interest in the data would likely arise from its contextualization within social realities;
- Comprehension of the data visualizations was expected to occur primarily through interaction with the platform;
- The pedagogical materials were anticipated to function as the main tools for supporting understanding and enabling students to draw conclusions about the topic.

These hypotheses guided the design of the workshop activities and informed the methodological steps detailed in the next subsection.

3.1 Stages of implementation

For the production of the workshop's pedagogical materials, we applied the scientific communication strategy framework of Besley and Dudo (2022), which proposes a three-part methodology: strategy, implementation, and evaluation. Rather than applying this model in isolation, we deliberately combined it with the iterative and generative principles of design thinking (Cross, 1982; Brown, 2010). While Besley and Dudo's framework provided the strategic orientation for defining objectives, audience alignment, and evaluation procedures, design thinking offered a flexible, practice-oriented process for brainstorming, prototyping, and iterating pedagogical materials. This integration ensured that the workshop was simultaneously guided by clear communication goals and open to creative adaptation in response to learners' needs.

To anchor this synthesis within a critical approach, we further drew on the perspectives of data literacy and critical pedagogy (Freire, 1968; D'Ignazio, 2022; Boyd & Crawford, 2012). In short, the strategic communication framework and design thinking structured the workshop's development, while critical data literacy perspectives shaped its contextual, reflective, and learner-centered tasks.

Our proposed methodology therefore consists of four stages: familiarization with the topic, strategy, creation, and evaluation (Figure 1).

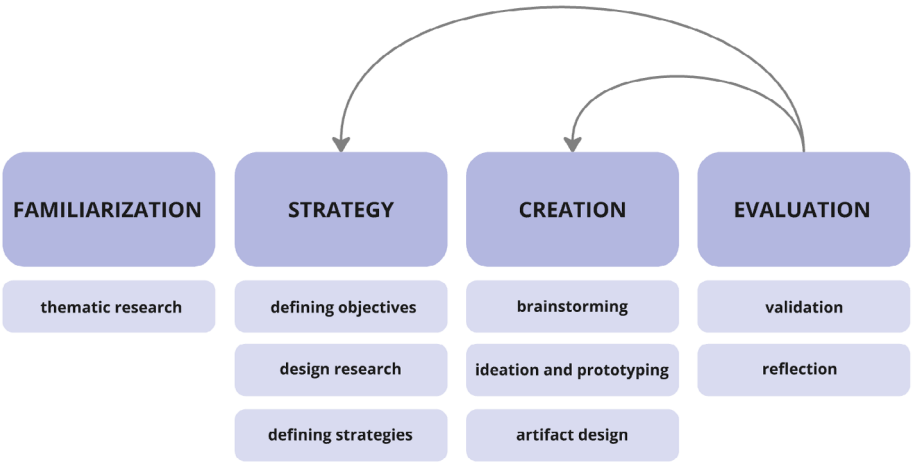

Figure 1 Proposed methodology for knowledge translation. Adapted from Besley & Dudo apud Souto et al. (2023).

In the **familiarization** stage, relevant information and data to be included in the pedagogical materials were collected. During this phase, the team engaged with the topic by exploring the *Amplia Saúde* platform and its tools.

In the **strategy** stage, following the steps outlined by Besley and Dudo (2022), key questions guided the definition of objectives: "*What behaviors, beliefs, or points of view do we want to change? What long-term changes do we want to see in society and the world?*" (p. 13). According to the authors, such questions inform design research and strategy development, which include sub-steps involving the identification of target audiences and the determination of appropriate formats, language, and graphic styles.

The **creation** stage employed brainstorming techniques and followed the ideation and prototyping process to design the pedagogical materials.

Finally, the **evaluation** stage focused on assessing the effectiveness of the pedagogical materials through validation tests. This stage occurred in two distinct moments: first, to assess the materials developed for the workshop; and second, through evaluation forms about the workshop itself, completed by the participating students and teachers. The detailed results of these evaluations are presented in the following sections, where we discuss both the effectiveness of the pedagogical materials and the reception of the workshop in classroom practice.

In the next section, we elaborate on the last two stages, given their importance for understanding the entire process.

4 Materials and pedagogical workshop creation

The iterative process guided all stages but especially the artifacts creation. Iterativity is one of the pillars of design thinking, emphasizing that project stages do not need to follow a linear path but rather a dynamic approach that involves adjustments and refinement of the artifact based on user observation and testing (Cross, 1982; Frascara, 2006; Brown, 2010). According to Cross (1982), the design process focuses more on exploring possible solutions (iterative cycles) than on analyzing and defining the given problem – being a "designerly way" of thinking the project.

For the development of the materials, we had to return to the *Amplia Saúde* platform, paying close attention to which content would be most suitable for the classroom. The platform offers two interactive visualizations: a map of Brazil, where each municipality is a population-scaled circle colored by one selected indicator, and trails, a sequence of line charts that let users compare social indicators across municipalities and socio-economic variables (e.g., schooling, race, maternal marital status) (Figure 2). While designing the workshop materials, we chose not to use air-pollution data originally presented in the visualizations because their influence on health outcomes were not clear. Besides this, maternal and neonatal data and indicators results already suffer multifactorial social influence, which could muddle the observation of patterns within a limited class time. Instead, we focused on neonatal health in relation to a single socio-economic indicator to yield clearer, more impactful insights.

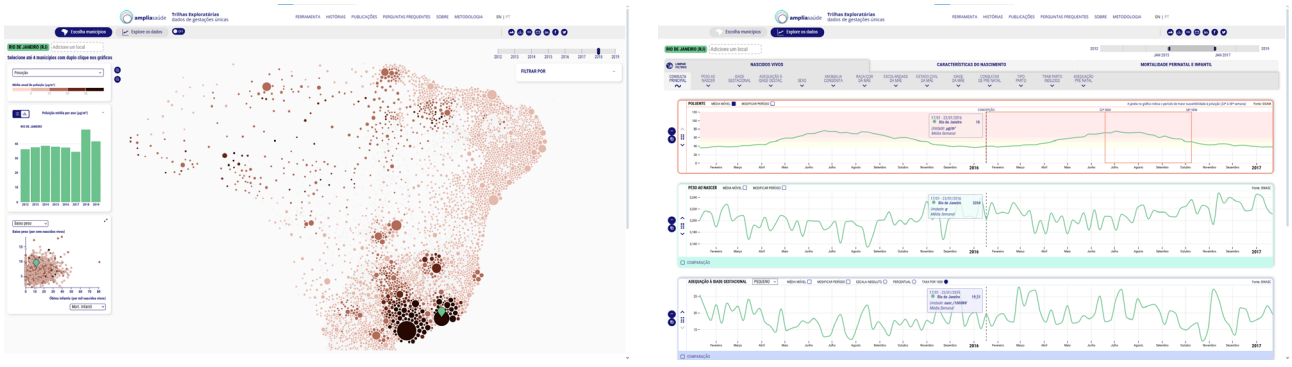

Figure 2 *Amplia Saúde* two visualization platform: map and trails.

We incorporated informal validation from specialists from both the health and educational fields, as well as professors from the design course. Along certain points in the iterative cycle, we asked these professionals their opinion on the pedagogical material – the graphic design, and the activities and questions proposed, both for the students booklet and the teachers support material, which led us to reduce the scope of the activities previously planned.

The teacher support material offered a broad perspective on the production and use of data in contemporary society, cultivate a critical

understanding of data that goes beyond technical skills, helping teachers build connections with data and fostering agency among all participants in the classroom, before giving instruction to high school teachers in planning and conducting the *Amplia Saúde* Workshop.

The student's booklet (Figure 3) focuses on the activity to be experienced in class, which was based on the following question: "How does the mother's education relate to the baby's health?" The students' booklets were printed to be used in class, whether the teachers support material was distributed in PDF format.

In addition to the students' activity booklet, a slide presentation was developed for the workshop. The presentation enables the workshop facilitator to introduce the topics of big data, data visualization, and the *Amplia Saúde* platform.

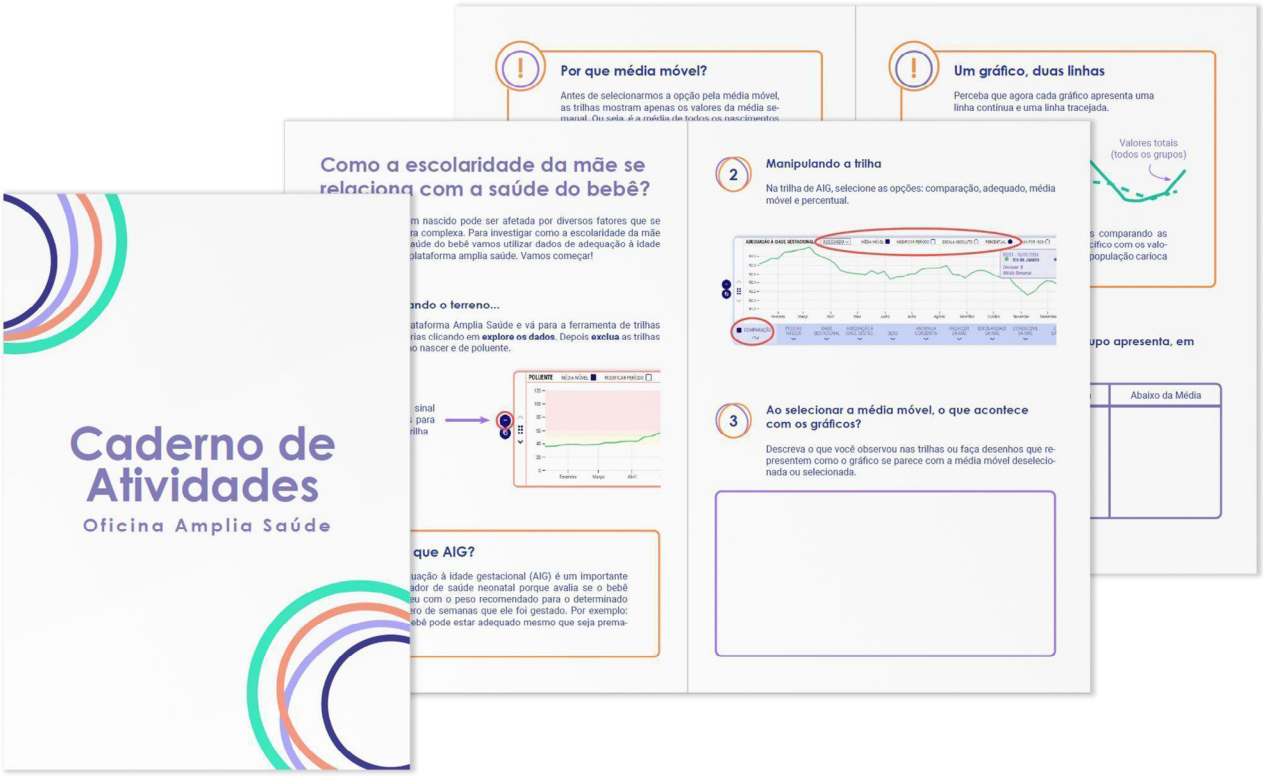

Figure 3 Students' activity booklet (Caderno de Atividades) and inside pages. The cover of the notebook reads "*Amplia Saúde* Workshop Activity Book," and the inside pages contain questions that relate the mother's education to the baby's health.

The workshop dynamics were organized into four stages: data exploration, hypothesis generation, intervention proposal, and collective discussion (detailed on the topic 5.1). With this dynamic, we wanted to place the student as the protagonist of their knowledge, which would be obtained actively through observation and group discussion. This approach follows the precepts of Paulo Freire (1987), who sees students as active agents in the teaching and learning process. For Freire, the starting point for any political

project is an understanding of reality and the forms of action and struggle that already exist on the ground. In this context, we understood that it would be important to identify the values and practices of the schools that could host the workshop in order to avoid friction with the institution.

5 The workshop application in the classroom

The *Amplia Saúde* workshop was held at the Application School of the State University of Rio de Janeiro (CAp-UERJ), selected for its distinguished role in promoting teaching and research in education through the Extension, Research, and Publishing Center (NEPE). CAp-UERJ, a primary and secondary school, is renowned for its commitment to the political education of its students, aiming to develop critical and participatory citizens who are aware of their rights and responsibilities. The institution has a strong democratic tradition and serves as a historically significant space for student mobilizations and discussions on contemporary social issues.[1]

1 Information collected from the institution's website. https://www.cap.uerj.br/institucional/

Reflecting its dedication to extracurricular activities, NEPE approved the workshops only after review and approval by the Research Ethics Committee. The NEPE team actively participated throughout the process, facilitating contact with teachers and providing access to computers for the activities.

A total of six workshops were conducted with 1st and 2nd-year high school classes in mathematics, chemistry, and drawing classes, involving students aged between 15 to 17. The main dynamic of the workshop centered on the use of the students' activity booklet and a computer with access to the *Amplia Saúde* platform. The questions in the booklet demand interaction with the platform, which requires students to engage with both digital and analog artifacts, relying on one to complement the other. The activity booklet, therefore, added a layer of physicality to the platform's visualizations.

The initial questions focus on the exploratory trails, proposing that students, in groups, can understand the meaning of appropriateness of birth weight for gestational age – an important neonatal health indicator, which is a factor presented on the platform. By interacting with the available line graph visualization options (the trails), students could begin to understand long-term trends by looking at the moving average. In addition, in this activity it was also possible to see that the higher the mother's level of education, the more appropriate the newborn's weight was to gestational age. This task was indicated in the activity booklet by illustrations that correspond to what can be seen on the platform (Figure 4).

Between interacting with the platform and answering questions, the students completed 8 activities, which leads to hypothesis for the fact observed. The last question of the workshop explored the whole process, proposing a discussion for improving maternal and newborn health in relation to its social and political aspects. At the end, all the answers were presented by the groups generating a debate on data visualization and maternal health.

Figure 4 Part of the guidelines in the Ampla Saúde workshop students' activity booklet. This topic reads: "Manipulating the trail", and a subtopic with guidelines on how to interact with the trail.

6 Analysis of results

In analyzing the workshop's results, we adopted a qualitative approach. Although some quantitative data were collected from the students' responses in the students' activity booklets, we also considered informal comments from teachers and students during the activities, as well as participatory observation by the authors. The research team presented in the workshop was composed of a postdoctoral researcher (first author), two undergraduate students with scientific initiation scholarships, and the professor responsible for the research (last author).

The workshop was very well received by the teachers who made their classrooms available, granting the research team freedom to conduct the activities. This openness reflects the relevance of CAp-UERJ's educational dynamics, which foster a liberating and problematizing perspective on education (Freire, 1987). The teacher support material was also positively received. Before the workshops, two teachers – one from mathematics and one from chemistry – reported that the material was insightful and even raised specific questions, which were later clarified through email exchanges with the team.

To analyze the results systematically, the activity booklets were collected and organized using a numbering system indicating the class and group (e.g., 1.4 = class 1, group 4). No student or teacher names were included. The students' responses were categorized into four dimensions of analysis:

1. Understanding of the graphs and data presented;
2. Understanding of maternal-neonatal health concepts;
3. Connection between the data presented and external factors beyond the workshop;
4. Proposed intervention.

For dimensions 1 and 2, responses were evaluated as adequate, intermediate, or inadequate. For dimensions 3 and 4, which involved more subjective responses, categories assessed whether the requested elements were present or absent, and whether the responses were satisfactory or unsatisfactory (Figure 5).

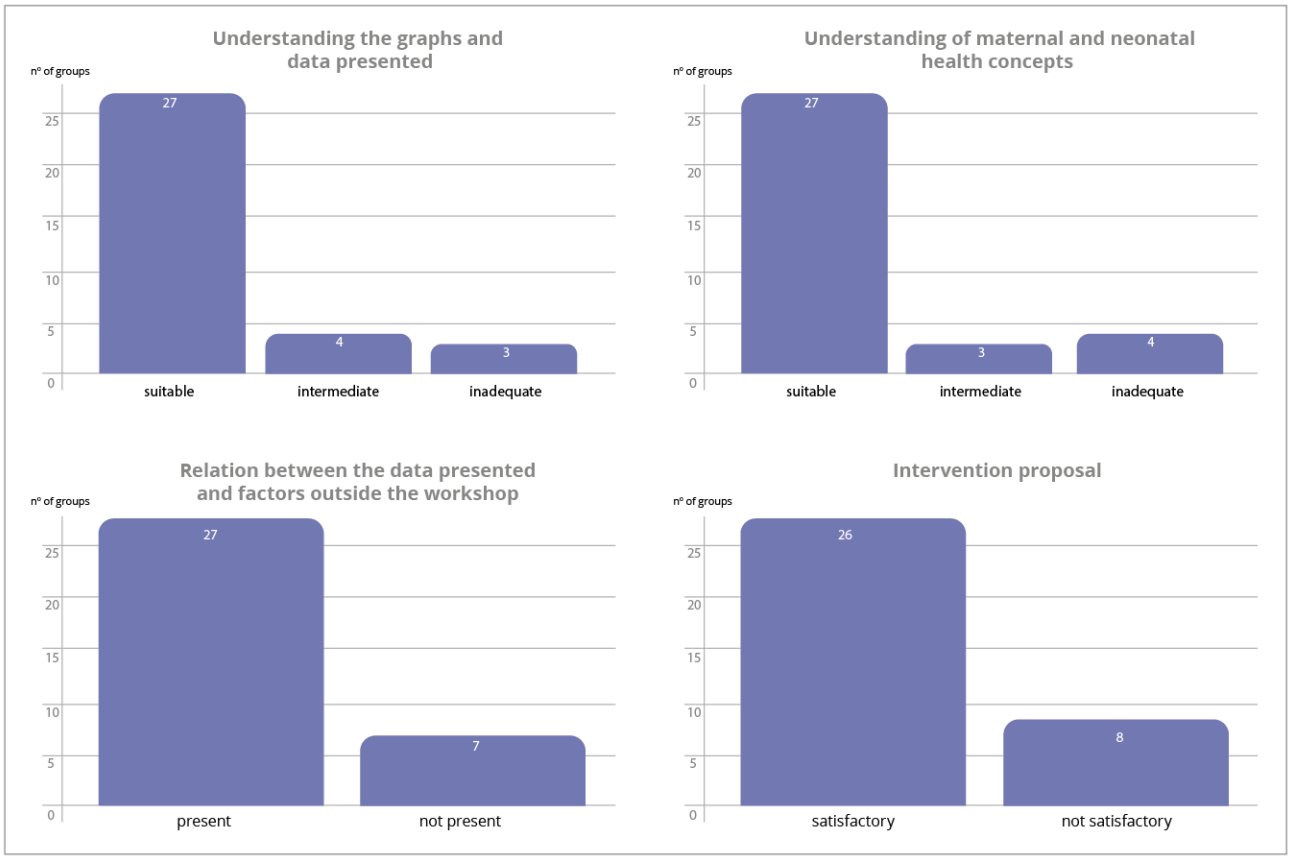

Figure 5 Graphics obtained from the students' answers. Source: from the authors.

From this analysis, very positive outcomes emerged, both in the written responses and through in-class observations. Below, we highlight points that recurred across groups and stood out for their relevance, accompanied by brief analyses based on our direct observations.

- **Reception of the activity booklet**. The booklet was well received by students. When distributed, groups showed enthusiasm to complete it, and the tasks encouraged interaction with the computer, which proved to be an additional source of engagement.
- **Positive perception of a different routine**. Students valued breaking from their routine. Comments such as *"Days like this make everything else worthwhile"* and *"It was a different experience, connecting various subjects and areas of study"* attest to their satisfaction at the end of the workshop. Engagement remained high even though students were told they could leave if they wished.

- **Misinterpretation of line graphs**. Three groups believed that the line graph referred to the care of newborn babies, leading them to attribute low averages to a mother's lack of ability to care for her child. Although not a majority view, this misunderstanding pointed to a negative aspect likely stemming from a lack of clarity in the wording of one question. We are considering revisions to avoid this issue in future editions.
- **Connections to unwanted pregnancies**. Many groups linked low AIG (Adequacy of Gestational Age) to unwanted pregnancies, which led to a high frequency of intervention proposals centered on sex education and condom use. The topic also surfaced in end-of-workshop debates, where students discussed peers' experiences with unwanted pregnancies and brainstormed possible mitigating actions.
- **Impact of education level on newborn health**. Many students were surprised to realize, through the data, that higher levels of maternal education correlated with better neonatal health indicators. This shock became a starting point for reflection, leading students to discuss possible causes (e.g., correlation between low schooling and reduced access to healthcare) and to propose potential solutions. This demonstrates the effectiveness of the workshop in using data visualization as a tool for critical reflection on social realities.
- **Perception of practical applications**. Several students noted the usefulness of the knowledge acquired. Representative comments include: *"I will use this as material for my essay repertoire"*; *"I enjoyed the work connecting statistics, politics, and material and social relations. It shows the real-world application of this data"*; and *"I learned how to interpret the graphs that appear on the TV news."*
- **Reinforcement through teacher participation**. Interest in data visualization increased when teachers explicitly connected workshop content to students' prior knowledge. For example, the mathematics teacher highlighted visualization elements linked to classroom topics, while in a drawing class the teacher discussed proportion and color in relation to the initial presentation.

Overall, both the students' activity booklet and the evaluation forms, which were answered at the end of the activity, showed that students engaged deeply with the workshop. Their interest and attention increased notably when information from the *Amplia Saúde* platform was tied to their own lived realities. Many of the proposed interventions urged government and state authorities to improve education quality for underprivileged populations. These responses indicate that the workshop stimulated not only data comprehension but also critical reflection on broader social issues.

7 Discussion

From the development of the workshop in the classroom, we understand that while the Scientific Communication Strategy by Besley and Dudo (2022) was useful for defining objectives and organizing pedagogical materials,

it proved limited for analyzing how meanings are negotiated in a classroom setting. Even the broader framework proposed by Bucchi and Trench (2021) – attentive to social, political, and cultural contexts – does not fully address pedagogical specificities. To foster a data-driven culture among non-specialists, we therefore turned to critical data literacy (D'Ignazio & Bhargava, 2016; Pangrazio & Selwyn, 2021; Tygel & Kirsch, 2016), inspired by Freire's dialogic education (1987).

We began developing the workshop by critically examining both the platform's visualizations – as designed artifacts that steer interpretation – and the students' readings as co-producers of meaning. In this way, we understand that visualization shapes attention and frames what can be perceived (Ratner, 2025), and claims to clarity encode choices and values, echoing critiques of neutrality and bias (Boyd & Crawford, 2012; D'Ignazio & Bhargava, 2016, 2018). Visualizations are interpretative constructs (Drucker, 2014) and, following Anne-Marie Willis as cited in Escobar (2018), a design that designs us back.

Given the persuasive power of data visualizations, the computer-based activities were consistently paired with the activity booklet. Each interaction was thus accompanied by questions or prompts for reflection – for instance, when students selected the moving average, they were asked: *what happens to the graphs?* This combination supported comprehension of data collection, categorization, and processing, while simultaneously deconstructing the appearance of "depoliticized neutrality" (Ratner, 2025). In doing so, the platform itself became open to critique, rather than being treated as a transparent or neutral conduit of information.

When reflecting on the hypotheses that guided the design of the workshop, the results offer important confirmations and nuances. First, the expectation that students' interest would arise from contextualization within social realities was clearly validated. Engagement increased when the visualizations were tied to familiar contexts, and students' proposals revealed their ability to connect health indicators to broader structural issues such as education and inequality. Second, the hypothesis that comprehension would occur primarily through interaction with the platform was only partially confirmed. While the platform supported understanding, episodes of misinterpretation showed that unguided exploration was insufficient. Deeper comprehension emerged only when interaction was combined with the structured prompts and mediating questions in the booklet. Finally, the prediction that pedagogical materials would serve as the main tools for supporting understanding was strongly confirmed. Both teachers' feedback and students' responses highlighted the central role of the booklet and related materials in scaffolding engagement and fostering critical connections between data and lived experience.

Taken together, these findings indicate that complex data visualizations on social and health issues can, under appropriate pedagogical mediation, generate insights that inform data-education initiatives. More importantly, such insights do not emerge from visualization alone but depend on didactic strategies that foster questioning, contextualization, and collective discussion. In this sense, the workshop responds to our research question

by showing that the guided use of complex visualizations not only promoted collective discussion and supported the development of adolescents' critical data literacy but also produced insights with potential relevance for broader, non-specialist audiences.

8 Conclusion

This study set out to investigate to what extent the guided use of complex data visualizations on social and health issues can promote collective discussion, support the development of adolescents' critical data literacy, and generate insights that may be transferable to initiatives targeting lay adult audiences. Through the design and implementation of a pedagogical workshop based on the *Amplia Saúde* platform, we examined how interactive visualizations, when paired with pedagogical materials, can become catalysts for reflection and dialogue in the classroom.

The findings largely confirmed our initial hypotheses. First, students' interest in the data was heightened when indicators were contextualized within their own social realities, for example when connecting health outcomes with issues such as education. Second, while interaction with the platform supported engagement, instances of misinterpretation showed that unguided exploration has limitations, partially confirming our assumption about comprehension. Third, the activity booklet and related pedagogical materials proved central in scaffolding understanding, validating our expectation that they would be the main tools for linking statistical indicators to broader social issues.

By linking these results back to the research question, we conclude that complex data visualizations can indeed foster collective discussion and critical data literacy, but only when embedded within pedagogical strategies that encourage discussion and reflection.

Although this study focused on high school students, the approach also suggests potential for broader application. In this sense, the workshop not only provides a model for classroom practice but also contributes to the wider effort of cultivating a citizenry able to interpret and question the data that shapes contemporary life.

However, this work has many limitations. The results derive from a single case in one public school, and the relatively small number of classes constrains generalization. The platform used also presents specific types of data and visualization designs, which may have influenced students' responses. Future research should therefore replicate the workshop in diverse educational and social contexts, test its applicability with different age groups, and explore adaptations for adult lay audiences.

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