

Cartography and Cognitive Neuroscience: Using Eye-Tracking to Investigate How 9 and 10 Year Old Students Read Thematic Maps

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Abstract: The importance of understanding maps is highlighted so that we are able to analyze, question, criticize, and act in the space in which we live. Aware of this, in an exploratory and innovative way, this research aimed to verify the visuo-exploratory behavior of 9 and 10 year old students when reading and interpreting thematic maps. We also investigated possible differences between groups based on variables such as gender, type of school (public or private), affinity with the subject of Geography, perceived difficulty in reading maps, and prior knowledge of the five cartographic elements (title, legend, compass rose, scale, and source). The sample consisted of 112 children, and the data were obtained through eye-tracking and questionnaires. The results indicated a visualization pattern for this age group, with a longer average fixation time on the caption and a shorter one on the title. There were no significant differences in average fixation time between the groups analyzed. This is a proof of concept study, situated at the intersection of Cartography, Cognition, and Teaching. It is hoped that the findings will attract attention and thus contribute to guiding more effective pedagogical strategies for teaching thematic map reading, especially for this age group. Although the main focus is educational, the results can also support the creation of more accessible maps, taking into account design aspects aimed at children. Finally, we hope that this work can encourage future research in a field that is still little explored.

Keywords: thematic map, eye-tracking, cognition, fixation, visuo-exploratory behavior

1. Introduction

The apprehension of the environment and the development of abstract structures to represent space have always been a constant feature of life in society, making maps popular for centuries (Harley, 1991). Considered a communication instrument, the map constitutes a language composed of symbols and codes of its own, the cartographic language, which needs to be deciphered to be understood (Rosolém, 2017).

Thematic maps in particular do not directly explain the aspects, facts and phenomena of reality, but rather verify and reveal this information, and it is up to the reader to ask questions and make assumptions from which a problem may arise and the premise for an investigation in search of explanations (Martinelli, 2017). Efficient reading of a thematic map requires the reader to perceive the map, interpret its legend, and understand the phenomena represented there. This process, in turn, depends on the acquisition of cartographic language, which does not occur spontaneously and requires systematic teaching.

In addition, the efficiency of map reading is related to the cognitive load of the task. The Cognitive Load Theory (CLT), developed by John Sweller (1988), deals with the limitations of working memory where information is temporarily stored and manipulated. Sweller proposed three types of cognitive load: Intrinsic Load, linked to the complexity of the content; Extraneous Load, related to

the way the content is presented; and Germane Load, which refers to the amount of mental effort needed to process, understand, and integrate new information into existing knowledge structures. The sum of these loads can result in cognitive overload, making it difficult to learn or perform a task.

According to Bunch and Lloyd (2008), maps can be valuable resources in the classroom, as they communicate complex information visually that would often be difficult to express verbally. However, if they contain too much information or are poorly designed, they can exceed the students' processing capacity, compromising learning (Mayer & Moreno, 2003, apud Bunch & Lloyd, 2008).

Given this, the teaching-learning process of cartographic language must be planned with attention to the cognitive particularities of the students. Mastery of this language is essential for the subject's critical and active inclusion in contemporary geographic space. For this to happen effectively, it is necessary to promote pedagogical strategies that consider the task's cognitive load and encourage the development of cartographic competence. From this perspective, studies investigating the interaction between the user and the map, the processes involved in cartographic comprehension, and the efficiency of graphic design are becoming increasingly crucial.

Based on these assumptions, this research investigated the visuo-exploratory behavior of 9 and 10 year old

students, enrolled in the 4th grade of elementary school, when reading thematic maps. The study also sought to identify possible differences between previously established groups, based on variables such as gender, type of school, affinity with the subject of Geography, perceived ease in reading maps, and prior mastery of fundamental cartographic elements (title, legend, compass rose, scale, and source).

We hypothesize that there is a characteristic visuo-exploratory pattern in the reading of thematic maps by children in this age group, with the area of the map acting as the main focal point. In addition, we hope to identify significant differences between the groups presented.

We believe that the results obtained in this study have the potential to interest both educators who work with cartography in the school context and cartographers. In the case of educators, the findings can help identify points of attention in the teaching/learning process of cartographic language and understand factors that influence students' reading and interpretation of maps. Although design is not the central focus of this study, the data can help cartographers take into account the cognitive specificities of this age group when designing more accessible maps. In both cases, understanding the visuo-exploratory behavior of 9 and 10 year olds when reading the thematic map can contribute to the development of resources that are more compatible with the cognitive processing stage of this age group.

2. Maps and Eye-Tracking (ET)

The Eye-Tracker (ET), an eye-tracking technique, is a device equipped with a camera and an invisible infrared light that illuminates the participant's pupil, generating a reflection on the cornea. The infrared camera registers this reflection and delimits the center of the pupil, inferring the rotation of the eyes to estimate the direction of gaze.

Since maps are visual stimuli, the eye-tracking technique has been widely used to investigate map perception to better understand user interaction with these cartographic resources. Over the past three decades, ET has been employed not only to examine map users' responses to map design and symbolization (Krassanakis & Cybulski, 2019) but also to track disparities or similarities between groups of different skills and abilities in map reading and interpretation tasks. Both strands of research converge in the search for more efficient and effective maps that improve the user experience and to obtain feedback that enhances the teaching of cartographic language.

In this context, Havelková and Gołębiowska (2020) investigated 25 undergraduate students specializing in geography and 16 doctoral students and employees of departments specializing in cartography. The aim was to identify differences between successful and unsuccessful users of the map reading task, focusing on the strategies used by those who provided incorrect answers. The results indicated that failure in the task was related to the inadequate distribution of attention, especially the lack of

focus on the thematic legend, which was neglected in most activities. Inspired by this study, we used a fictitious thematic map based on the content of atlases and school geography textbooks as part of our research.

Trokšiar et al. (2022) analyzed the behavior of 20 students aged between 17 and 20 years when interacting with different types of maps, including thematic maps. During the analysis of thematic maps, the participants paid more attention to the legend before focusing on the face of the map. However, the legend was used less on hypsometric maps. Like Havelková and Gołębiowska (2020), Trokšiar et al. (2022) analyzed map use strategies through areas of interest (AOIs) and investigated students' choices when solving multiple-choice tasks with the help of Eye-Tracker. In contrast, the present study is limited to exploring the participants' visuo-exploratory behavior without worrying about the strategies used or asking them direct questions about the map's content.

Beitlova et al. (2020), in another study focused on thematic maps, investigated how 30 high school students (~18 years old) and their teacher read thematic maps of different types present in a school world atlas. Among the results, they highlighted that some difficulties in map reading tasks were associated with inadequate cartographic visualization methods, such as the difficulty of distinguishing some symbols in the legend. In addition, the study showed that the geography teacher adopted a different approach to solving the tasks, as she only consulted the legend in some of them. Even though the authors suggest that the comparison between students and teachers may reveal some of the difficulties students face when reading maps, the fact that the analysis was based on just one teacher raises questions about the representativeness and quality of the results obtained.

Other studies have also looked at user interaction with maps, although with different approaches to our research, especially concerning the efficiency of map design and the elements that make it up.

The work of Ooms et al. (2012, 2013), widely cited in the field, sought to understand users' cognitive processes while working with maps to improve map design. The sample consisted of 31 participants in the first study and 24 in the second, differentiated between experts, master's degree students in the field of Geography, and novices, bachelor's degree students from another field. The study did not use a thematic map as we did, and the authors' concern was related to the map's design.

Although using thematic maps, the study by Šutinienė et al. (2024) investigates the understanding of conventional symbols by high school students. Like the work by Ooms et al. (2012, 2013), the research by Šutinienė et al. focuses on aspects related to the design of maps, intending to improve graphic efficiency and user interaction with their elements. In contrast, our research seeks to investigate the visuo-exploratory behavior of participants, exploring how different groups interact with thematic maps, without focusing on the design itself.

Another point of divergence is that our sample was not divided between novices and experts, as in the studies by Ooms et al. (2012, 2013), Havelková and Gołębiowska (2020), and Beitlova et al. (2020). Instead, the groups were defined based on gender, type of school (public or private), interest in Geography, perceived ease or difficulty in reading maps, and knowledge of the five map elements (title, legend, compass rose, scale, source).

As in the aforementioned studies, we also used ET to investigate user interaction with the map. However, our study differs in several aspects: the type of map used (thematic), the absence of a sample division by skill level, the secondary focus on map design, and the lack of questionnaires or tasks. In the meantime, the most significant divergence concerning the studies presented is the age range and the size and variety of the sample. While previous studies have investigated young people and adults, our study analyzed 112 children aged 9 and 10 with a wide socioeconomic diversity.

The literature lacks investigations with this combination of age group and use of thematic maps in an eye-tracking context. Inferring adult results for this audience can lead to essential errors, especially considering the development of Executive Functions, which directly impact the cognitive load of the task. Based on our research, this is one of the first studies to use eye-tracking with thematic maps in children of this age group and with a diverse sample of more than 100 participants. The work also stands out for covering three major areas: Teaching, Cognition, and Cartography.

We believe that children aged 9 and 10 are at an early stage of familiarization with reading thematic maps. For this reason, we believe that exploring the visuo-exploratory behavior of this group can reveal important aspects for improving the user's relationship with the map from different perspectives: educational, cognitive and cartographic. From an educational point of view, the results may indicate points of attention that could be related to the difficulties that students face when reading maps, providing support for teachers to plan more effective interventions, and direct their mediation towards weak aspects of the teaching-learning process of this language. From a cognitive perspective, the analyses can provide insights into the mental load involved in the tasks, making it possible to avoid overloads that compromise learning. From a cartographic perspective, the results may help to identify map elements that require greater caution in terms of their design, providing support for cartographers to make the experience of reading this language more fluid and accessible for this age group.

We believe that improving these three perspectives - educational, cognitive and cartographic - will contribute significantly to the development of competence in cartographic language, enabling students to become more skillful and efficient readers of one of the most relevant communication tools, whose presence will extend throughout their lives: the map.

3. Objective

The main objective of this work is to investigate, through eye-tracking (ET), the visuo-exploratory behavior of 9 and 10 year old students during thematic map reading and to see if there is a pattern for this age group. We will also check whether there is a difference between different established groups, such as: female and male; type of school, public or private; affinity with the subject of Geography, do not like studying Geography, indifferent to it or like it; perception of difficulty in reading maps, whether they find map reading difficult, medium or easy; prior knowledge of the five cartographic elements, such as title, legend, compass rose, scale and source.

4. Materials and Methods

4.1 Sample Characterization

The empirical part of this study involved 112 students of both sexes, aged 9 or 10 and regularly enrolled in the 4th year of basic education (Brazil). Students who were repeating school years, those with a developmental disorder or those with a physical disability that prevented them from taking part were not included in the study. The study was submitted to and approved by the Ethics Committee of the Federal University of ABC (Brazil) under protocol CAAE 69739723.0.0000.5594.

There were four participating educational institutions, two municipal public schools and two private schools located in the Metropolitan Region of São Paulo (Brazil). Both public schools are located in the subprefecture of Cidade Tiradentes, a region with an MHDI¹ (2010) of 0.708. One private school is located in the subprefecture of São Mateus, region with an MHDI (2010) of 0.732, and the other private school is in the municipality of Santo André, and has an IFDM² (2010) of 0.856. These indices show the wide socioeconomic variability of the participants.

The sample was well-distributed (Table 1), with almost equal numbers of male and female participants, as well as the type of school. The difference in terms of period is explained by the fact that both public schools only offer classes in the afternoon.

Table 1: Table relating to the characterization of the sample.

¹ The Municipal Human Development Index (MHDI) is an index that combines education, income and life expectancy at birth. To begin with, it uses basic understanding of living conditions and is thus able to provide an easy visualization of socio-economic comparisons in the urban environment of the city of São Paulo. Available at: <https://www.prefeitura.sp.gov.br>

² The IFDM - FIRJAN Municipal Development Index - is a study that annually monitors the socio-economic development of all of Brazil's more than 5,000 municipalities in three areas: Employment & Income, Education and Health. It uses the same classification scale as the IDHM. Available at: <https://www.santoandre500anos.com.br>

Sexes		Schools		Period	
Female	55.75%	Public 1 and 2	46.43%	Morning	30.36%
Male	43.36%	Private 1 and 2	53.57%	Afternoon	69.64%

4.2 Materials

We used the following materials to collect the data: **Q1** - a questionnaire designed by the authors to characterize and evaluate the research participants, which contained questions about the student's relationship with cartography; **ET** - Eye Tracker, a portable Gazepoint hd - 150Hz device, which was used to track the student's eyes while they looked at the map; **Gazepoint Control and Analysis software®** - software that was used to record the ET data and then analyze it; **Thematic map** - map prepared using ArcGis® software³, with fictitious qualitative and quantitative data, and the mapped phenomena were selected based on an analysis of geography textbooks and school atlases (the choice of colors and their different shades ensured that color-blind students could distinguish them); **Jamovi software** - software used for statistical analysis⁴.

The empirical part was carried out in two stages, both in the school environment. The first occurred in the classroom, where **Q1** was given to each student to fill in. The questionnaire contained questions about the student's relationship with geography and cartography. We offered five graded answer options for both questions, with 1 relating to negative aspects and 5 to positive aspects. The student had to select only one alternative per question. We also investigated the students' knowledge of the five elements of the map with questions about them. They had to tick "yes" or "no", and if they ticked 'yes', they had to explain what that element was, for example, "Do you know what the map title is? If yes, explain".

The second stage took place individually, in a room provided by the school and with as little light interference as possible. A brief explanation of the research took place to ensure that the student understood its dynamics. The ET was then calibrated so that the thematic map could appear on the screen. The student looked at the map for approximately 20 seconds without any specific guidance, just keeping their eyes on the computer screen while the ET collected the data. The ET calibration was performed for each participant, and a head support ensured data quality.

The statistical analyses were based on the questionnaire data (Q1) and eye movement metrics captured by the ET. To obtain the eye movement metric data, we created 6 AOIs (Areas of Interest) corresponding to the five elements (title, legend, compass rose, scale and source) of

the map and the map itself. Using the Gazepoint Control and Analysis software®, we obtained the average fixation time and the number of revisits to each AOI.

With the questionnaire (Q1) applied, we obtained information such as: students' opinion of their enjoyment of geography, students' opinion of the degree of difficulty in reading maps, and knowledge of the five elements of the map. We then cross-referenced the data from the questionnaire (Q1) with the ET data to check for differences and similarities between groups based on variables such as gender, type of school (public or private), affinity with the subject of Geography, perceived difficulty in reading maps, and prior knowledge of the five cartographic elements - title, legend, compass rose, scale and source.

5. Results

The results obtained according to each analysis described in the previous section will be described.

5.1 Questionnaire (Q1)

The graph presented below represents the qualitative data regarding the students' responses obtained with the questionnaire (Q1). For the questions "Do you like studying Geography?" and "Do you think it's good to read maps?", we combined the groups that selected 1 and 2, and those that selected 4 and 5. The analysis was carried out between the three groups: Negative (answers 1 and 2), Mild (answer 3), and Positive (answers 4 and 5). We can see in the graphs below (Figures 1 and 2) that almost 70% of the students enjoy studying Geography, and almost 60% find it moderately difficult to read maps.

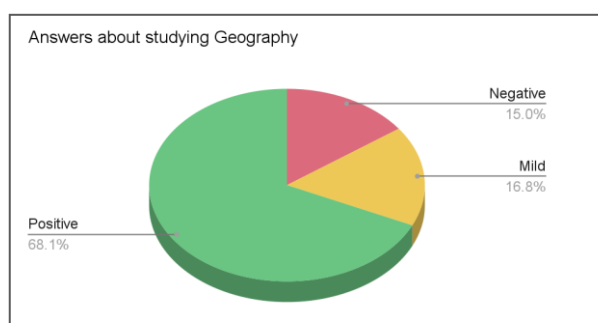
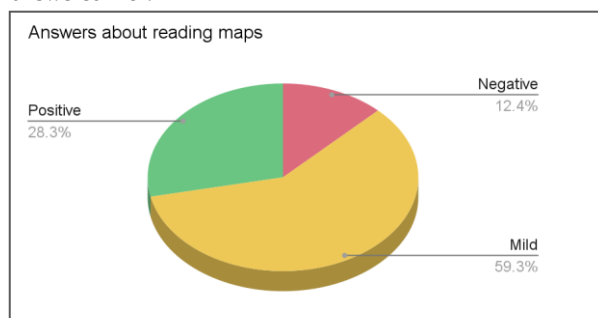


Figure 1: Graph referring to the student's interest in Geography. The provided responses were: 1 - I don't like, 2 - I don't like much, 3 - Indifferent, 4 - I like, 5 - I like a lot. The group labeled "Negative" corresponds to students who answered 1 or 2; "Mild" to those who answered 3; "Positive" to those who answered 4 or 5.



³ The maps were made by the geographer Lígia Carvalho Sena, 2023.

⁴ Jamovi, available at: <https://www.jamovi.org/about.html>.

Figure 2: Graph referring to the student's level of difficulty in reading maps. The provided responses were: 1 - Very difficult, 2 - Difficult, 3 - Average, 4 - Easy, 5 - Very easy. The group labeled “Negative” corresponds to students who answered 1 or 2; “Mild” to those who answered 3; “Positive” to those who answered 4 or 5.

For the questions about the elements of the map, we combined the individuals who answered that they didn't know what such an element was with those who answered that they did know but that their answers were wrong. Analyses were carried out between two groups: “Know and get it right” and “Don't know or made a mistake”. Around 80% of the students didn't know or gave wrong answers about the five elements of the map, and the rest knew some elements. The graph below (Figure 3) shows that the wind rose and the title are the elements the students know the most about, while the scale and source are the ones they know the least about and/or got wrong. Regarding the compass rose, this result is mainly because in one of the participating schools, the students had just had an explanation about it.

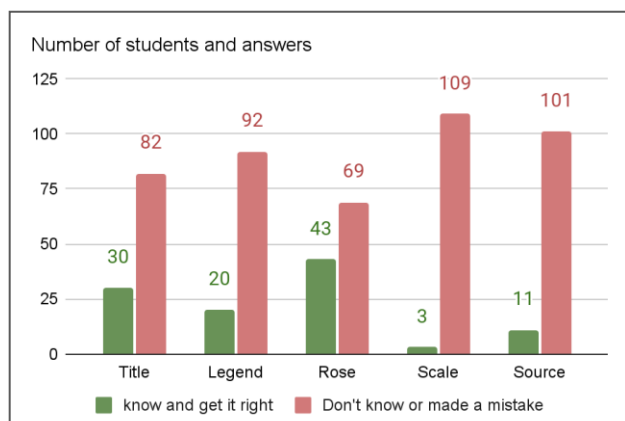


Figure 3: Graph showing the number of students (vertical axis) in relation to their knowledge of the map elements (horizontal axis). The groups were divided into “Know and get it right” and “Don't know or made a mistake”, and the analysis was done for each element.

5.2 Fixations and Revisitations in Relation to the Map

The results obtained from the fixation times and revisits according to the AOIs (Areas of Interest) established (Figure 6) are shown in the graphs below (Figures 4 and 5). In the first (Figure 4), we can see that the areas of greatest interest to the students are the legend area, followed by the map area. Elements such as wind rose, scale, and source are ignored by most of the participants. The second graph (Figure 5) shows that the map is the area most revisited by students, and that the title has more revisits than fixations. The Heatmap (Figure 7) confirms that the legend is the region of greatest fixation for students, since a red spot is found in this AOI.

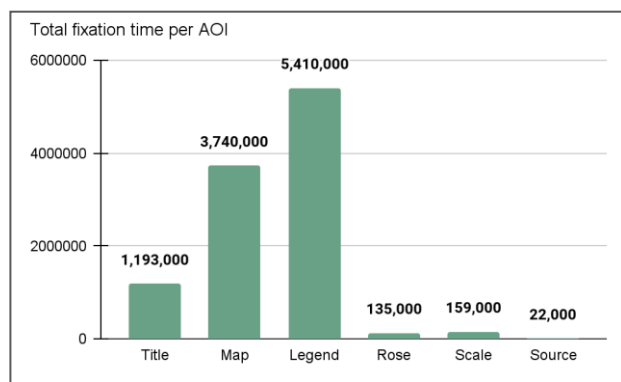


Figure 4: Graph referring to the average fixation time in milliseconds according to each established AOI.

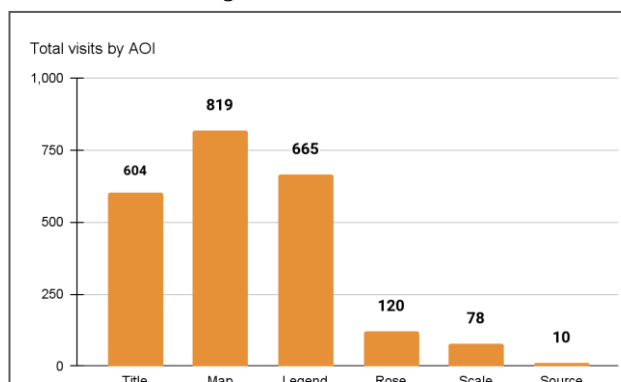


Figure 5: Graph referring to the number of revisits according to each established AOI.

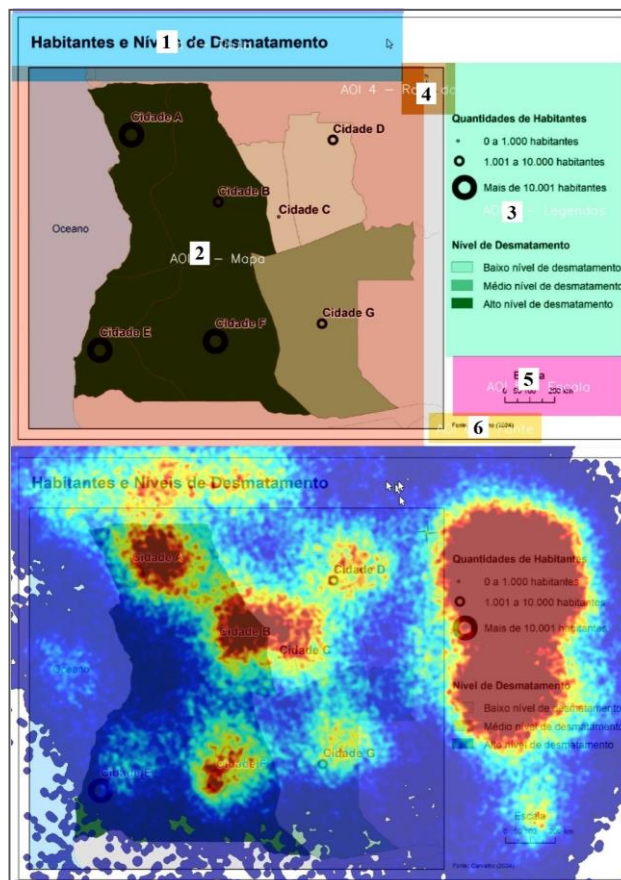


Figure 6 and 7: The first map (Figure 6) represents the 6 AOIs drawn in different numbers and colors: 1) Title - blue, 2) Map area - red, 3) Legend- green, 4) Compass rose - brown, 5) Scale - pink, 6) Source - yellow. The second map (Figure 7), is a heatmap where warm colors represent higher values and cool colors represent lower values. It can be observed that the highest concentration of fixations is on the legend.

5.3 Comparisons Between Groups

The average fixation time of the six defined AOIs: Title, Caption, Compass Rose, Scale and Source (Figure 6) was used to compare the following groups:

- **Sexes:** Female (n=63) and Male (n=49);
- **Institution:** Public (n=60) and Private (n=52);
- **Interest in Geography:** Individuals who “do not like studying Geography” (n=17), “indifferent” (n=19), and those who “like” (n=76);
- **Ease of Map Reading:** Individuals who find reading the map “difficult” (n=14), “average” (n=67), and “easy” (n=31);
- **Right and Wrong Answers:** Individuals who answered correctly and incorrectly the questions about what each map element is, focusing only on the title, legend, and compass rose due to the group size (Figure 3).

For the analysis of groups 1, 2, and 5 (comparison between two groups), we used the Mann-Whitney U-test; for groups 3 and 4 (comparison between three groups), we used the Kruskal-Wallis test. These choices are justified because the analysis groups are independent and do not follow a normality curve. The p-values obtained in the all analyses show that there was no significant difference in the groups with Type I Error of 5%.

6. Discussion

This article describes an exploratory and innovative study in which we mapped the visuo-exploratory behavior of 112 9 and 10 year old children during the reading of a thematic map using the Eye-Tracking (ET) metric. In addition, we evaluated whether there were differences and/or similarities in the average fixation time between different AOIs (Areas of Interest) according to the groups established.

The results showed that both the legend and the map area were the AOIs with the longest average fixation times, with revisits occurring most frequently in the map area, followed by the legend and the title. These findings partially corroborate our initial hypothesis that the map area would be the main focal point. However, the fact that the legend received the highest number of fixations was surprising, even though it occupied a smaller area.

Our results are only close to the work of Trokšiar et al. (2022), who, when analyzing the interaction of young people with thematic maps, observed that the participants paid more attention to the legend before exploring the map itself. However, this comparison should be made cautiously since the age difference between the groups is relevant. In addition, the reason for the high fixation on

the legend observed in the study by Trokšiar et al. (2022) was attributed to the students' difficulty distinguishing some of the symbols on it. However, the limitations of this study prevent us from reaching this kind of diagnosis.

Even aware of these limitations, our hypothesis for the high fixation on the legend is that it could be related to either curiosity or difficulty in reading and interpreting this cartographic element. Considering the second option as the most plausible, another possible hypothesis is that this high fixation is associated with the cognitive load of the task.

Considering all this, the legend deserves special attention. As a central element for understanding the information on thematic maps, the legend stands out as a critical point of interaction between the user and the content. For this reason, its construction requires care from a cartographic and educational point of view. Both areas must work together, based on cognitive principles, to reduce the effects of the phenomena previously described, such as the task's Cognitive Load (CLT), and provide a more accessible and effective learning experience.

Cartographers have traditionally been concerned with using symbols, colors, and scales that favor the decoding of information when designing maps. However, we suggest that specific research into the preferences and difficulties of younger age groups could guide more appropriate design decisions. Such studies would allow the choice of more intuitive and accessible solutions for children, especially in teaching materials, contributing to the reduction of Intrinsic Load by making the task more compatible with the students' level of familiarity.

In the field of education, this concern is amplified. Teachers must pay special attention to the legend, promoting activities encouraging contact with different formats and symbolic cartographic conventions. In addition, it is essential to ensure that students have developed the ability to decode this element before moving on to more complex stages of cartographic reading, such as the correlation between the information on the map and the real world. This approach helps reduce the effects of Germane Load by ensuring that cognitive resources are directed towards constructing meaningful schemas and not consumed by initial interpretation difficulties.

Another relevant aspect identified in the research is the low average fixation time of the map title. Like the legend and the mapped area, the title is a fundamental element for reading and interpreting thematic maps. However, our results indicated that around 25% of the students did not look at this component, despite considering it, in second place, as one of the most well-known elements of the map. Given that the title plays a strategic role in summarizing the content and guiding reading, its visual neglect can significantly compromise the efficiency of the interpretative process.

This finding reinforces the need to value the title in the cartographic literacy process. In the school context, it is recommended that teachers not only explain the function and importance of this element but also promote activities that encourage its interpretation and analysis. For example, exercises involving the choice or creation of titles can increase students' awareness of their relevance. At the same time, cartographers are responsible for drawing up titles with accessible vocabulary that aligns with the linguistic repertoire of the age group in question. Such practices help to reduce Intrinsic Load, making the reading process more fluid and accessible to children in the learning phase.

As a third and final point, we highlight the similarity in visual behavior patterns between the different groups in the sample, which contradicts the initial hypothesis of this study. Despite the significant socioeconomic disparity between the participating schools, the results suggest a possible uniformity in teaching school cartography in the Metropolitan Region of São Paulo, SP (Brazil). This inference should be considered cautiously, as it requires more targeted and in-depth research, including comparisons with children from other cultural and educational backgrounds.

The novelty of the approach and the methodological robustness employed support this study's relevance. We used thematic maps associated with questionnaires and eye-tracking technology, applied to a significant sample of 112 children aged between 9 and 10, with considerable socio-cultural diversity.

Nevertheless, it is essential to recognize some limitations inherent in the study. Among them, we highlight the impossibility of standardizing the size of the Areas of Interest (AoIs), since the cartographic elements vary according to the graphic conventions of each map. Consequently, larger areas tend to generate longer fixation times, which can influence the recorded data. It is also worth noting that we did not relate eye fixations to attentional cognitive processing, as proposed by the eye-mind hypothesis (Just & Carpenter, 1980). Since this theory is not yet a consolidated consensus in the literature, we chose to focus our analysis on the participants' visuo-exploratory behavior, understood here as a preliminary stage of selective attention. We recognize that an in-depth study of the cognitive processes involved in map reading requires the use of complementary methodologies.

Finally, we didn't ask the students about the possible reasons for their high fixation on the legend, for example. Our choice was aimed at preventing noise, based on the concept of "social desirability" (Holtgraves, 2004), which refers to the need to meet the expectations of the environment. Future studies could benefit from the limitations of this research by integrating different approaches, such as interviews, performance tests, or neurophysiological measures, to broaden our understanding of the cognitive dynamics involved.

Based on the findings presented, we raise some questions that could guide future research: (1) Would the lack of fixation on the title be associated with less efficient reading? (2) What are the causes of high fixation on the legend? (3) Are these visual patterns replicable in other cultures, or does the socio-cultural context have a significant influence on map reading?

This research represents one of the first investigations to use eye-tracking technology to analyze the visuo-exploratory behavior of 112 children aged between 9 and 10 when interacting with the thematic map. We consider its contribution to be innovative as it is situated at the confluence of three major areas of knowledge: Teaching, Cognition, and Cartography, and as it offers a relevant starting point for filling gaps in the literature, especially concerning understanding the processes involved in map reading by children. As Arthurs et al. (2021) point out, there is still limited understanding of the specific cognitive strategies used in this type of task.

As a final consideration, we reiterate that this is a proof of concept study, the aim of which is to lay the foundations for future research. We believe that exploring how children in the process of cartographic literacy interact with thematic maps can provide valuable input for the work of teachers and cartographers, promoting the formation of more proficient readers in this language that is fundamental to contemporary social inclusion.

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