Experiencias Docentes

Lectura e interpretación de una representación gráfica engañosa

Reading and interpreting a misleading graphical representation

Carla Santos

Cristina Dias

Revista de Investigación

G.I.E Pensamient Matemátic MAIC

Volumen XI, Número 2, pp. 047–054, ISSN 2174-0410
Recepción: 24 Ago'20; Aceptación: 9 Sep'20

1 de octubre de 2021

Resumen

En la sociedad basada en datos del siglo XXI, el uso de representaciones gráficas está muy extendido en los medios de comunicación, anuncios comerciales, informes técnicos y comerciales e investigación científica. Aunque la información en los gráficos estadísticos a menudo se considera clara para los destinatarios, la literatura proporciona una amplia evidencia de que la comprensión de los gráficos es una tarea compleja.

En una tarea que consiste en leer e interpretar un gráfico de barras con el eje de ordenadas truncado, la mayoría de los estudiantes tuvo dificultades para interpretar el contenido de lo gráfico, alcanzando solo el primero de los tres niveles de la taxonomía de comprensión gráfica de Curcio.

Palabras Clave: Alfabetización estadística, educación superior, desinformación, ejes truncados, gráfico de barras.

Abstract

In the 21st century data-driven society, the use of graphical representation is widespread in the media, commercial advertisements, technical and business reports, and scientific research. Although statistical graphs are often considered clear to the recipients of the information, the literature provides extensive evidence that graph comprehension is a complex task.

In a task involving the reading and interpretation of a bar graph with truncated y-axis, most students showed difficulties in interpreting the content of the graph, reaching only the first of the three levels of Curcio's taxonomy of graphical comprehension.

Keywords: Axis truncation, bar graph, higher education, misinformation, statistical literacy.

1. Introduction

In modern society, a wide range of communicative, analytical, and technological skills is required. Looking at some of the definitions of literacy (e.g. Kirsch et al., 1993, Benavente et al., 1996, Murnane et al., 2012), they all focus on possessing the skills to access, process and communicate information. Since much of this information appears in the form of numbers or graphs, the ability to understand and use numerical information, coined by the term numeracy, has become indispensable in personal and professional life (Steen, 1999).

In the 21st century, numeracy is critical for the understanding of the world, taking part in many domains belonging to a broad modern concept of literacy, such as health literacy, media literacy, political literacy and financial literacy. Today´s data-driven society requires every citizen to have statistical culture, regardless of his profession or qualifications, so one of the main aspects of numeracy is statistical literacy.

From the 90s of the last century there was an increasingly strong call for statistics education to leave the traditional approach, based on procedures and computations, and to focus on statistical literacy, reasoning, and thinking. Despite all recommendations and changes in school curricula, the reality of the study of statistics at basic and secondary level has not changed considerably to strengthen students' statistical literacy (Zieffler et al., 2008, Sabbag & Zieffler, 2015), as evidenced by the difficulties that many higher education students reveal when developing studies that require the use of statistical tools and the interpretation of data.

Statistical graphs are very powerful communication tools, ubiquitous in the media, commercial advertisements, technical and business reports, and scientific research. The rapidly increasing availability of statistical graphs produced by computer programs and applications, afforded their widespread use in all areas of society, emphasizing the need for statistical literacy for all individuals, as citizens and professionals, which led to reviews of school mathematics curricula at all levels of the education system.

As emphasized by the saying "A picture is worth a thousand words", statistical graphs allow to display large amounts of data, clearly communicating the insights of that data in a way that words could hardly achieve.

Despite the frequent contact of most individuals with statistical graphs, there is evidence in the literature that many people cannot read and interpret graphs properly, even the simplest ones (e.g. Dreyfus and Eisenberg, 1990, Glazer, 2011). One of the factors suggested for that is the specificity of statistical reasoning, which "being an artefact of civilization, not part of our natural neural equipment" (Moore, 1998, p.1257), requires to be learned and exercised.

For higher education students it is imperative to be statistically literate, since their ability to use the appropriate statistical tools, in the development of studies in their future professional field, will enable them to make informed decisions.

As noted in the literature (e.g. Friel, Curcio & Bright, 2001), and in our practice as higher education teachers in courses requiring basic statistical literacy skills, many students do not master reading and interpreting of graphs, not even a basic bar graph.

In this work, we describe and analyse an activity that encompassed a task of reading and interpreting a bar graph, which was deliberately oriented towards a preconceived target. The aim of the task was to promote students´ critical thinking when confronted by information in graphic representations leading to biased conclusions, like those they encounter frequently in day-by-day life.

2. Representation of statistical data in bar graphs

2.1. Graph interpretation

Organising data in graphs is relevant not just for representing data, but also for finding relationships between variables, determining patterns, and identifying data properties. Thus, statistical graphics became an indispensable tool for decision making, in all areas of society, and their use is now widespread.

Since the late twentieth century, there has been a growing concern with the identification of factors involving the understanding of information contained in representations of statistical data (e.g. Galesic & Garcia-Retamero, 2011; Arteaga et al., 2011; Ratwani, Trafton & Boehm-Davis, 2008; Mautone & Mayer, 2007; Friel, Curcio & Bright, 2001; Kosslyn, 1985) and "interpretation of graphs" has been defined differently by different authors. Friel, Curcio & Bright (2001) consider "interpretation of a graph" as the ability to extract meaning from that graph, recognizing the constituent elements of the graph and their conformity, critically analyzing the influence of each of these elements on the transmission of information, translating the relationships established between the graph design and the data it represents and evaluating the adequacy of the graph. For Wu (2004) the interpretation of a graph refers to the ability to formulate opinions about the information expressed in the graph and the design of that graph. According to Monteiro & Ainley (2004), the interpretation of graphics is much more than a simple technical procedure, involving a wide range of knowledge, experiences, and feelings.

Each type of graph has its own specifications and its own language (Friel, Curcio and Bright, 2001), however, in order to be able to draw as much information as possible from any graph it is necessary to have certain skills. To assess the ability of critically read the data present in statistical tables and statistical graphs, Curcio (1989) distinguished the following three levels in the comprehension of data.

(I) reading the data;

(II) reading between the data;

(III) reading beyond the data.

(I) represents an elementary comprehension level that only requires a literal reading of the graph, this is, the description of the facts explicitly expressed in the graph or table, with no interpretation.

(II) represents an intermediate comprehension level that requires the understanding of the data, the ability to make comparisons and combinations and to find trends, and the use of mathematical concepts and skills.

(III) represents an advanced comprehension level that requires the use of information that is neither explicitly nor implicitly stated in the graph to make predictions or inference, this is, requires extrapolation from the data.

The number of variables presented in a graph is one of the ways to categorise graph complexity. A simple graph representing one or two variables, like line graphs, scatter plots, bar graphs and pie graphs, requires little domain knowledge to interpret it (Glazer, 2011). Still, interpreting this type of graph is not simple for everyone, and doing so can become even more difficult if the graph design includes aspects that distort the perception of the data it represents.

2.2. Graph manipulation

Graphic representations of data, in general, and bar graphs, in particular, allow people to readily communicate and analyse data, however, many common graphical designs lead to engaging imagery but false interpretations and conclusion.

Fulfilling its primary purpose, graphs allow almost immediate assimilation of the information encoded in their design. When looking at a graph, it is common to focus attention on the most prominent aspects and neglecting the others. If the observer does not have the proper skills to read this graph critically, this observation may lead to a misinterpretation of the content.

Graph characteristics, such as format, colour or type can affect graph comprehension, but the perception of the information, contained in a statistical graph, can be intentionally biased by factors such as the obscure intentions with which some graphs are drawn and the aspects that may be neglected, intentionally omitted or adulterated in these graphs (e.g. Huff, 1954)

The scales of a bar graph are often manipulated to minimize differences between categories or to make them seem much larger. Another possible way to exaggerate differences in categories frequencies, and bias the information transmitted by a bar graph is y-axis truncation. This technique visually distorts the frequencies of the categories by beginning the y-axis of a bar graph at a value other than the typical zero.

3. Method

This study is part of a research of a group of higher education teachers, responsible for courses, requiring basic statistical literacy skills, in Portuguese polytechnic institutes.

The task we here describe and analyse consist in reading and interpreting a bar graph, which was deliberately designed to exaggerate differences, through y-axis truncation. The activity, of which this task is part, was structured taking into consideration the aspects that, in the literature, are identified as influencing the understanding of bar graphs. The graph in this task is often used by us to trigger a discussion about the importance of reading and interpreting graph skills and alert to distortion techniques used in graphing.

The participants in this study were forty-three students attending courses requiring statistical tools, belonging to management, social sciences, and health degrees of polytechnic higher education. The students performed the activity during a class of 60 minutes.

The graph we used in this task represents the number of beneficiaries of social inclusion income, in Portugal, in 2017 and 2018.

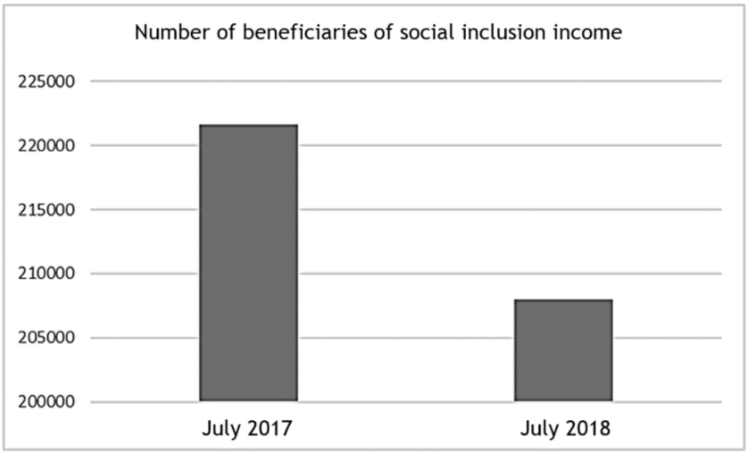

Figure 1: Bar graph used in the task
Source: Authors of the paper, using data from http://www.seg-social.pt/estatisticas.

Based on the observation of the graph, students were asked to comment on the statement " In 2018, there were less than half of RSI beneficiaries than in 2017".

Data was gathered from the students' answer sheets and analysed through content analysis, regarding the influence of y-axis truncation in the interpretation of the graph, the identification of the errors made by the students and the levels of graph comprehension achieved.

4. Results and discussion

Among the students' answers, 19 were correct, 10 partially correct and 14 incorrect.

Responses that provide valid arguments regarding the disagreement with the sentence under consideration, accompanied by the correct calculation of the percentage supporting that disagreement, were classified as correct.

The answers that disagreed with the sentence under consideration but were not substantiated by the computation of the percentage, reflecting the relationship between the quantities, were considered partially correct.

Only one of the students thoroughly justified the difference between the frequencies, presenting the percentage computation accompanied by a description of how y-axis truncation makes it difficult to immediately analyse the graph content.

Among the 14 wrong answers, 12 were caused by negligence of the y-axis truncation or because they could not identify the variable or understand the scale. The other 2, were non-sense answers.

Regarding the levels of Curcio's taxonomy of graphical comprehension, thinking over the statement associated with the graph only involves the most elementary level, requiring the literal reading of data, the comprehension of the scale and units of measurement and the identification of the variable. Whereas, to support the comment, the calculation of a percentage would be necessary, so the task also involves the intermediate level of comprehension of graphics, with the use of prior mathematical knowledge.

The intermediate level in comprehension of graphics was achieved by 44% of the students, those whose answers were classified as correct. 37% of the students (10 with partially correct answers and 6 with wrong answers) were at the elementary level of graph comprehension. The remaining 8 students (19%) were unable to extract any relevant information from the graph.

Overall, students faced difficulties in interpreting the graph content, achieving mostly the first of the three data comprehension levels. Less than half of the students, participating in the study, were able to reach level II in data comprehension. It is noteworthy that y-axis truncation was a relevant factor in the cases of unsuccessful interpretation of the graph.

The results of our study led us to conclusions in line with those found in the literature on this subject, proving that the study of Statistics is not a guarantee of the acquisition of the basic skills of statistical literacy (e.g. Pereira-Mendoza & Mellor, 1990, Wu, 2004, Watson, 1997 and Arteaga *et al*., 2011).

The literature is very limited in studies on the skills of higher education students in the interpretation of bar graphs, with most studies related to future students of primary education. In our study, students demonstrated a lack of skills to extract information from a bar graph. These findings were in line with other studies (e.g. Monteiro, Selva & Ferreira, 2000, Yang, Restrepo & Stanley, 2019).

5. Conclusion

The power to summarize large volumes of data and understand the most relevant characteristics of these data has made Statistics an indispensable working tool for researchers, as well as for the dissemination of numerical information in all fields of society.

Taking advantage of the technological development and the emergence of computer programs and applications that facilitate the elaboration of statistical graphs, the use of these graphs has become widespread in today's society, becoming essential elements, in scientific articles, technical reports, politics, sports or advertising. As a result, statistical literacy became component of adults´ numeracy.

The proposed task consisted of reading and interpreting a simple bar chart, like those that often appear in the media. In order to enhance biased interpretations, in situations of negligence in observation or limited skills in the comprehension of data representations, authors designed a graph with truncation of the y-axis, exaggerating differences between categories.

Through the analysis of the students' answers, it was possible to identify their errors and difficulties as well as to evaluate the level of comprehension of data, expressed in a bar graph.

Reflection on the results of this study provides us with an opportunity to adapt the teaching methods and strategies implemented in the U.C. that we teach in order to respond appropriately to the need to educate citizens capable of consciously producing, decoding and using statistical information in their personal, social and professional lives.

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Sobre las autoras:
Nombre: Carla Santos
Correo Electrónico: carla.santos@ipbeja.pt
Institución: Instituto Politécnico de Beja, Portugal

Nombre: Cristina Dias
Correo Electrónico: cpsd@ipportalegre.com
Institución: Instituto Politécnico de Portalegre, Portugal