STATISTICAL LITERACY OF CITIZENS: THE INTERPRETATION OF STATISTICAL GRAPHS

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This article analyzes how a group of Venezuelan citizens interprets two bar graphs. The reading, interpretation, and evaluation of statistical graphs is part of the competences that an ordinary citizen must possess. It was therefore decided to ask ordinary citizens to interpret two statistical graphs. The questions are part of a broader questionnaire that was published on the survey administration platform and sent to potential participants using non-probability sampling. The questions were answered by 407 citizens with different levels of academic training. The results show that most participants gave plausible arguments to support a specific position but had difficulties in critically evaluating a graph. These results are a first approximation on how Venezuelan citizens interpret statistical graphics and can be a reference for statistical literacy processes.

INTRODUCTION

For several decades now, most countries have included statistics as one of the components of the general education of all citizens. The aim is for every citizen to attain statistical literacy, understood as:

> (a) people's ability to interpret and critically evaluate statistical information, data-related arguments, or stochastic phenomena, which they may encounter in diverse contexts, and when relevant (b) their ability to discuss or communicate their reactions to such statistical information, such as their understanding of the meaning of the information, their opinions about the implications of this information, or their concerns regarding the acceptability of given conclusions. (Gal, 2002, pp. 2–3)

Understanding statistical graphics is one of the essential elements of statistical literacy (Gal, 2002; Garfield & Ben-Zvi, 2007). For this reason, this paper reports how a group of Venezuelan citizens analyze statistical graphs. A first bar graph is proposed to them, from which they are asked to generate arguments to support a certain position. They are then asked to evaluate a statement made from a second graph. They must indicate whether they agree or disagree with the statement and offer arguments. These two situations allow us to describe the ability of this group of citizens to critically interpret statistical graphs. The information of this study can be a reference for the revision of the statistical education processes of Venezuelan citizens.

METHOD

The work we present is a descriptive study, using a questionnaire with survey technique. A task taken from the PISA 2003 report (Instituto Nacional de Evaluación y Calidad del Sistema Educativo (INECSE), 2005) was selected (see Figure 1). The task presents an educational situation, so it can be considered an understandable context for all citizens. According to INECSE (2005), it is a non-routine problem that requires linking different aspects of information to find a solution, reflect on a graph, and communicate their interpretations. According to Friel et al. (2001), the task is classified as a *Read Beyond the Data*. To answer it successfully, people must generate new information from the data; the information is not read directly from the graph.

Using the same situation, a second question was generated, but it was formulated on a new graph (see Figure 2). The graph shows an apparent important difference between the two groups. We want to find out if citizens go beyond the initial impression and contrast the interpretation made by Group A with the graph. According to the reading levels of Friel et al. (2001), it is a task of *Reading behind the data*. They must make a critical appraisal of the conclusions from the graph. These are situations similar to those that a citizen might encounter when reading an article in the media.

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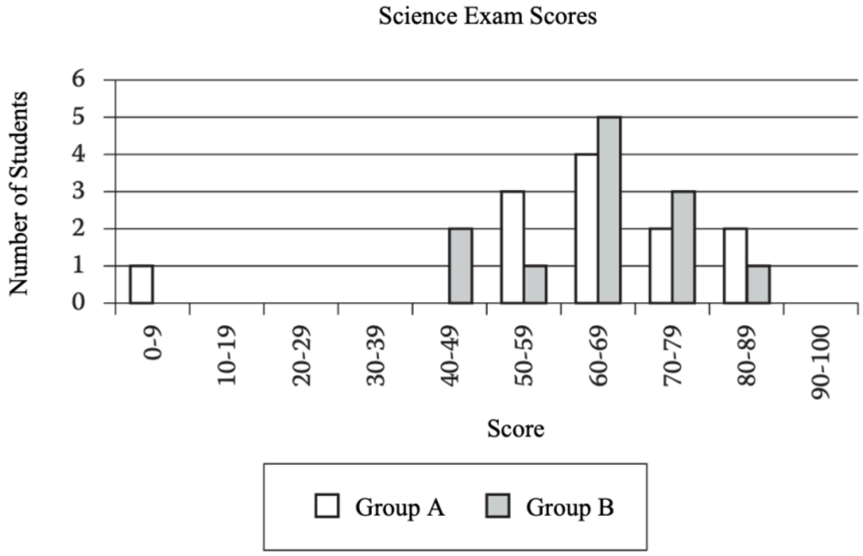
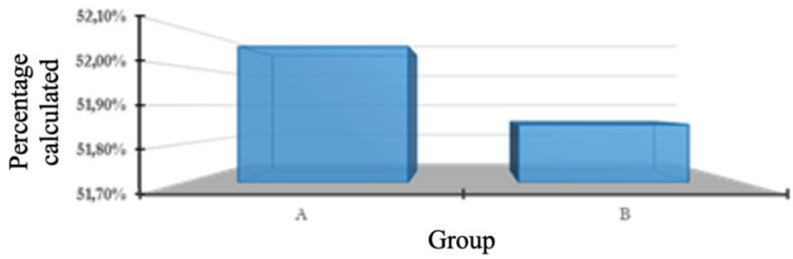
The graph below shows the results of a science test for two groups, labeled Group A and Group B. The average score for Group A is 62.0 and the average score for Group B is 64.5. Students pass this exam when their score is equal to or higher than 50.



Looking at the diagram, the teacher states that Group B was better than Group A on this exam. The students in Group A disagree with their teacher. They try to convince the teacher that Group B does not necessarily have been the best on this exam. Give a mathematical argument, using the information in the diagram that the students in Group A can use. (INECSE, 2005, p. 50)

Figure 1. Question 1 on science exam scores

The students in Group A asked the teacher to provide them with the grades of all the tests taken by the two groups during the school year. With that information they calculated the percentage of tests in each group where all students had passed and constructed the following graph.



The students in Group A showed the teacher the graph and state that their performance is far superior to that of Group B. Do you agree with Group A's statement? Argue your answer.

Figure 2. Question 2 about the percentage of students passing the science exam

The questionnaire was posted on the Google Forms platform. It was sent to potential participants—people known to the researchers or their family members—and from there snowball sampling (non-probability) was used. The aim was to get responses from citizens in general, with a diversity of academic backgrounds. Informed consent was included at the beginning of the questionnaire. The sample consisted of 407 citizens. The majority were female (57.5%), with an average age of 42.7 years and a standard deviation of 15.9 years, which suggests that this is a heterogeneous group in terms of age (minimum 17 years, maximum 85 years). All were university graduates. Some 23.6% were students, 23.6% were graduates without postgraduate studies, and 52.8% were graduates with postgraduate studies. All reported having studied statistics at university.

To evaluate question one, the PISA criteria were used, according to which valid arguments can be related to (a) the number of students who passed the test, (b) the disproportionate influence of the extraneous case, and (c) the number of students with higher level scores (INECSE, 2005, p. 50).

Participants' responses were individually and independently examined and rated by each researcher. The rankings generated were compared and discussed to produce a single ranking. A similar procedure was used with the arguments provided by the participants in question 2, only in this case, the categories emerged from the analysis conducted during the discussion of the researchers' rankings.

RESULTS

Table 1 shows the results of the first question.

Table 1. Frequency and percentage of responses to question one

Arguments	Frequency	Percent
Incorrect	142	34.9
Correct	256	62.9
No response	9	2.2
Total	407	100

Table 1 shows that the majority (62.9%) of the participants indicated some of these arguments proposed by PISA or combinations of them. This means that they offered arguments, supported by the graph, that Group A could use to convince the teacher that Group B did not necessarily have a better performance in the exam under consideration.

The most used argument is linked to the number of students passing the exam in each group (33.7% of the total). Respondents point out that in Group A there are more passing students than in Group B (e.g., *Group A has 11 approvals, while Group B has only 10*). The second most used argument refers to the fact that Group A has a greater number of students with 80 points or more (e.g., *could argue that group A (2 students) obtained one of the highest scores than group B (1 student), being between 80–89 points*). This argument accounts for 11.3% of the total number of responses. These two arguments can be extracted directly from the graph. Four people (1%) observed that there is an outlier in Group A and that, if it were omitted, the mean of A would be higher. This reasoning is not derived exclusively from reading the graph. It is necessary to identify the extreme case in the graph and relate how it may affect the mean.

There are also responses where two or more of the above arguments are combined. Those combinations gather 11.4% of the total number of answers, and the most used one is where both the higher number of passing students and the high grades that Group A has been mentioned (*e.g., Group B failed more students and the maximum grade was achieved by 2 students from group A and only 1 from group B*). This combination accounts for 8.6% of the total number of responses.

The arguments classified as incorrect are grouped into three categories. First, they point out that the performance of the groups is similar (5.9% of the total), e.g., *Group A scored 70 to 90, similar to group B*. These are responses that do not offer arguments that could be used by Group A; they consider that both groups have a similar performance. They do not give answers to those requested. Second, group B has a better performance, e.g., *Students in group B have better grades than those in group A, as shown in the graph*. They also do not give answers to what was requested; they argue that B has superior performance. They represent 10.8% of the total. Third, participants offered answers where the reasons are not related to the values or trends in the graph and are considered to be idiosyncratic responses (Aoyama, 2007), e.g., *The two groups studied*.

In Figure 2, there is an apparent significant difference between the two bars, but when examining the ordinate axis, it is observed that the difference between the groups is only 0.25%. Therefore, there is no correspondence between the graph and what is stated by Group A, that their performance is far superior. Table 2 shows the results of the second question.

Unlike the previous question where the majority of the group offered valid arguments, in this situation, the majority pointed out arguments considered incorrect. Only 15.5% of the total responses showed disagreement with Group A's assessment and supported their responses with adequate arguments. These are responses that note the small percentage difference between the two groups and use it to refute Group A's statement.

Table 2. Frequency (percentage) of responses to question two, according to type of argument

Response	Incorrect	Correct	No response	Total
Agree with group A	211 (51.8)	43 (10.6)	2 (0.5)	256 (62.9)
Disagree with group A	88 (21.6)	63 (15.5)	0 (0.0)	151 (37.1)
Total	299 (73.4)	106 (26.1)	2 (0.5)	407 (100)

A smaller number, 10.6% of the participants, noted that the percentage difference between the groups was small but still considered Group A to be a far superior performer. The arguments of these respondents reveal some empathy with Group A; do not mention the graph or its values; and rely on general reasons, with little or no statistical basis. Similar arguments are made by those respondents who disagree with Group A's statement but rely on arguments with no statistical basis. They seem to disregard the information in the graph and prefer to be in solidarity with Group B. These sets of responses seem to match the Personal Perspective, from the hierarchy of Fernandez et al. (2019), because it offers a personal response without considering the data in the graph.

The majority of these participants (51.8%) assume that the difference between the bars in the graph is important and choose to support the interpretation made by Group A. In their arguments, they state that there is a large difference in performance in favor of A. These citizens could be misled by manipulated or misinterpreted statistical graphs.

CONCLUSION

The results of the first question indicate that the majority of participants were able to offer valid arguments to support a specific position. Most of the arguments were derived directly from the graph. In the second graph, the majority of this group of citizens evidenced difficulties in evaluating the graph and generating an adequate interpretation. When responses suggest empathy with Group A or arguments are not linked to the graph, respondents could be using the emotional part that Batanero (2004) considers is also used when interpreting graphs, along with knowledge and skills.

Although it is presumed that they received statistical training in secondary education and all reported having taking statistics courses at university level, an important part of this group of citizens showed difficulties in making a critical interpretation of a bar graph, such as those used in the media. On the other hand, few link the information in the graph with the arithmetic mean. This could be because this type of relationship is not frequent when studying graphs. Both aspects should be considered in a revision of the statistical education of Venezuelan citizens.

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