

## INTERPRETATION OF PICTOGRAMS BY 3<sup>rd</sup> GRADE PUPILS: THE TEACHER'S ROLE

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*In this paper we analyze how a primary school teacher (João) leads the discussion of a task in a grade 3 class aimed at reading and interpreting pictograms. The paper is part of a larger study that follows an interpretative and qualitative research methodology with a case study design. The results indicate that, in his teaching practice, the teacher strives to ask questions so that his pupils are not limited to the identification of categories of high and low frequency characteristic, that is, "reading the data", but also raises questions related to "reading between the data" and "beyond the data."*

### INTRODUCTION

Statistics is a part of global education, helping future citizens to obtain reading and interpretation skills of tables and graphs that appear daily in the media and fostering the development of critical thinking based on data. Martins and Ponte (2010) advocate the inclusion of statistical education since the elementary levels of education contributing to the development of a critical and participative citizenship. Although the Statistics curriculum of many countries includes the teaching of graphics as a topic since the beginning of education, the pedagogical emphasis is aimed more at aspects relating to construction rather than the interpretation of graphs (Monteiro & Ainley, 2010). In this paper, we intend to examine how the questions posed by a 3<sup>rd</sup> grade teacher in his class promote reading and interpreting of pictograms by pupils.

### READING AND INTERPRETATION OF STATISTICAL GRAPHS

The link between school and everyday life can be achieved by statistics taking advantage of the presence of various types of data in the media (Arteaga, Batanero, & Contreras, 2011). According to these authors, one of the components of statistical literacy we need to develop in pupils is the ability to interpret and critically evaluate statistical information represented in graphs, as this also constitutes an important part of statistical culture.

Graphs comprehension can be defined as the ability to derive meanings from graphs created by others, or by themselves (Friel, Curcio, & Bright, 2001). Reading and interpreting graphs requires knowledge of their structural elements and their conventions - such as title, labels, axes, scales, represented variables and figurative elements (lines, points, bars). It also requires an integrated reading and interpretation of these structural elements.

The skills related to reading and understanding of statistical graphs have been studied by various authors and the classification proposed by Curcio (1989) is the one that had the greatest impact on statistical education. It includes the following levels:

- Reading the data: direct reading of the graph without interpreting the information contained. Pupils should just respond to direct questions.
- Reading between the data: interpretation and integration of data in the graphs. This capability requires the comparison of the data or the identification mathematical relationships;
- Reading beyond the data: this includes the organization of predictions and inferences based on the interpretation of data on information that is not directly reflected in the graph.

In addition to the interpretation of graphs, Aoyama's classification (2007) considers a critical evaluation component of the information contained in the graph, reflecting on the following levels:

- Rational/literal level: Pupils can correctly read the graphs and detect tendencies but they do neither question the information nor suggest alternative explanations. They identify the relationship between variables but they do not try to explain it.
- Critical level: Pupils read the graphs, understand the context and assess the information reliability, sometimes questioning the information presented.
- Hypothetical level: Pupils read the graphs, interpret and evaluate the information to create their own explanatory hypotheses.

González, Espinel, and Ainley (2011) suggest the idea of graphical competence including (i) the ability to extract information from different types of graphs and to interpret meanings from reading the data; (ii) the ability to select and create graphs suitable for specific situations, with or without the support of technology; and (iii) the ability to critically assess graphs and to distinguish the strengths and limitations of certain graphs. From their perspective, teachers are faced with the challenge of developing their analytical competence of graphs and mastering the required knowledge for their accomplishment in the classroom, as this is an important purpose of Statistics' teaching.

### THE TEACHER QUESTIONING

The participation and involvement of pupils in the entire data processing process are key aspects in the interpretation of the graphs to which the teacher should be particularly alert to. Friel, Curcio, and Bright (2001) point out that asking questions is closely connected with the understanding and that "teachers need to develop a framework to help them think of questions to be asked. This question-asking framework is important for the understanding of graphs" (pp. 129-130). To these authors, different levels of questions promote different levels of graphical understanding, so the teacher should pose questions that are not limited to extracting data from graphs; but they should also allow for the identification of relationships as

well as prediction and generalization, thus fostering development of the ability to understand graphs.

Friel, Curcio, and Bright (2001) define three levels of questions that the teacher should use to foster the graphical understanding levels considered by Curcio (1989). The elementary level questions require information gathering to respond to immediate questions which can be easily identified in the graph. At the intermediate level, questions aim at integration and interpretation of the available information in the graph and the search for relationships between data. Finally, the advanced level questions require extrapolation of the data and the analysis of the implicit relationships in the graph. Although Friel, Bright, and Curcio (2001) believe the advanced level questions, allowing to "read beyond the data", are the most challenging and contribute to a deeper understanding of the data structure, they believe that it is necessary to contemplate the three types of questions to promote the process of graphical comprehension.

### **METHODOLOGY**

This study is part of a broader research work in a collaborative work environment, involving the first author and three teachers from the 3<sup>rd</sup> and 4<sup>th</sup> grades, with the purpose analyzing their professional practices for teaching organization and handling of data. Working sessions include preparation of tasks and the discussion and reflection of their exploration in the classroom. In these sessions, the researcher streamlines sessions; he helps with the preparation of the tasks and with the reflection over their accomplishment. The collaborative group decided to work on investigative tasks relating to the daily lives of pupils, involving the formulation of research questions, collection and organization of data, presentation and justification of conclusions (Martins & Ponte, 2010).

We have followed a qualitative research methodology of interpretative nature, using the case study method (Stake, 2007). In this paper, we intend to examine how the questions raised by João (one of the case studies) promote the reading and interpretation of pictograms by pupils. Originally, this teacher has a degree in Primary Teaching, and he completed his training in the Universidade Aberta (Open University) as a Portuguese Language major. At the beginning of the study, he had been teaching for 33 years.

Data were collected through classroom observation, with video and audio recording, supplemented with interviews, participation in workshops and collection of materials produced by pupils. Data analysis is based on three levels of questions for graphical understanding proposed by Friel, Curcio, and Bright (2001).

### **THE TASK "SCHOOL PUPILS' TELEVISION PREFERENCES"**

In the initial class [January 29, 2013] teacher and pupils decided to ask the following question for study: "What are our favourite TV programs?" After some discussion, they wrote on the board the name of the type of television programs to be voted

(documentaries, cartoons, soap operas, news, movies and sports) and they choose their favourite programs. The data was placed in a table which contained the name of each pupil. They created a table of frequencies and a pictogram and they formulated conclusions with reference to the analysis of the collected data. From the discussion conducted, came the idea of extending the study to other classes in order to find out the preferences of their colleagues. At a later class, teacher and students planned the data collection work in each class to carry out this study.

### **Preparation**

*Collection and analysis of pupils' television preferences.* Pupils organized themselves in groups and went to other classrooms to explain to their colleagues the work they were conducting and what they wanted to find out about their television preferences. They distributed a ballot and explained that they should just put a cross on the type of favourite television programs and another cross on gender to differentiate the preferences of boys and girls. Before the vote, they also explained what they meant by each of the types of program. After the voting, the ballots were collected, put in an envelope and brought to their class for organization and processing of data.

In class of March 2, 2013, teachers and pupils recollected the work they did and identified the steps for continuing the study. They started by counting the data and organized it into frequency tables, separated by boys and girls with the respective graphical representation. As they had done for their class, they would be building pictograms, allowing for comparisons with the choices from their classmates. To finish the work, the pupils should be drawing conclusions for each class. We should note the teacher's reminder to perform a careful reading of the graphic so as to "discover interesting things". The various groups received the envelope with the ballots from each class; they performed a counting of the choices and built a frequency table. They got a paperboard to create the pictogram and they proceeded to make the respective measurements of the space to be occupied by each data category, making sure to keep them separated from one another. In order to represent the choice of each pupil, they used a square of paper with an image [smiley face]. They painted the square blue if the data belonged to a boy and pink for girls. They glued them and put a legend on each category and they started creating designs that facilitate their identification [Appendix 1 and 2].

*Formulation of conclusions.* After creating the pictograms, each group analyzed their data and started to formulate conclusions. The teacher went around through the groups asking them to read texts produced and corrected writing and grammar aspects in sentences. His interventions were aimed at helping pupils to formulate conclusions. He was worried about the pupils analyzing the information provided by pictogram in order to answer the study question. In addition, he was asking other questions to challenge pupils with the intent of getting them to identify other more "interesting" aspects represented by the pictogram, enabling comparisons and relationships between values expressed by the various categories. Finally, he suggested that the text was organized according to a certain sequence of sentences.

## Interpretation of results

*Beginning of discussion.* After the formulation of conclusions, the teacher asked pupils to distribute the paperboards with the respective pictograms though several areas of the room so that would be visible to everyone. The following is a presentation of the findings from each group, with a pupil doing the reading while another pupil indicates in the pictogram the data referring to the findings. The following paragraph refers to the presentation of the conclusions class AC from the 2<sup>nd</sup> grade:

The type of program chosen the most was cartoons. The second most chosen program was sports. The types of programs less chosen were the news and documentaries. They were both chosen by the female gender. It's balanced, the cartoons were chosen by 5 boys and 5 girls. The difference between the cartoons and sports is 4 choices. The soap operas have 6 less choices than cartoons.

The group that dealt with the data from this class began by identifying the key aspects revealed by the pictogram, i.e., programs which were chosen more and less. At this stage pupils were only "reading data". At a second stage, their analysis indicates that the choices of the less preferred programs were made by the female pupils, and then they moved to another type of analysis looking for differences between the choices of the different types of programs. Their references evolve into "reading between the data."

*Choices of girls.* In the following interventions, after having read the findings for each group, the teacher asks the class to participate in the discussion of the data presented. He began by suggesting that they should look at the pictograms carefully, looking for "interesting things" and he asked several questions to support pupils in their analysis. After the presentation of the conclusions from the AC class from the 1st grade, the following dialog occurred:

- Teacher: Look, where are the girls' preferences going?  
 Pupils: To documentaries.  
 Teacher: To documentaries. And now look at the pink spots scattered there, where are the other pink spots going?  
 Pupils: To soap operas.  
 Teacher: One for the soap operas and...  
 Pupils: To the news and movies.  
 Teacher: And to the movies. And how many girls chose the documentaries?  
 Pupils: 7.  
 Teacher: Seven. Now then make the sum of the other girls, from the other pink spots.  
 Pupils: We already know.  
 Duarte: 4.

- Teacher: Four. Who has something to say about this? Here are seven girls (in the documentaries). And then there is one (he is point at the graph), two, three, four. Isn't this interesting?  
 Pupils: It is.  
 Teacher: And what's interesting here? What can we say here? Leandro?  
 Leandro: Girls who have chosen the documentaries in the type of program, they all together make up more than all of the others separated.  
 Teacher: That's right. So what can we still say? Something else. Fabio, you say it. I don't know if you've heard Leandro. Leandro explained it to me a bit clumsily but he said: seven girls there and the others are only four.  
 Fabio: Most girls chose the documentaries.  
 Teacher: Isn't that interesting? A while ago, I told you to open your eyes. Most girls chose...  
 Pupils: Documentaries.

João tried to get pupils to focus on aspects of the graph that went beyond simply reading the data, identifying more and less chosen programs. In this case, he suggested an observation over the choices of girls from this class. The teacher wants pupils to see that most girls focused their votes in choosing "Documentaries". Seven girls chose this type of program while the other four were scattered over the other programs. This episode revealed the questions of intermediate level asked by the teacher, aiming to support pupils in reading the graphs so as to develop skills which go beyond a "reading of the data", but which allowed them to move to a "reading between the data" - in this case, focused on the distribution of frequencies relating to the choices of girls.

*Justification for the choice of documentaries in the 1<sup>st</sup> grade.* During the presentation of the AC class data from the 1<sup>st</sup> grade, one of the pupils -Leandro - goes with a possible justification for the preference of documentaries by most pupils from this class, the taste for programs on animal wildlife:

- Teacher: The debate is open. I'm enjoying the debate. Let's go.  
 Leandro: In the 1<sup>st</sup> grade, I think they chose documentaries because they may enjoy the wildlife.  
 Teacher: Yes, possibly.  
 Leandro: I like it a lot.  
 Teacher: And they also like it.

Leandro did not simply note that "documentaries" were the most chosen type of program but he was trying to "read beyond the data". He provided a justification for why the choice did not go to cartoons unlike in almost every other class. Leandro included programs on "wildlife", which he personally prefers in the category

"documentaries", thus using information that was not available in the graph. Leandro's intervention followed the teacher's invitation to participate in the debate.

*Balanced choices of boys and girls.* In the presentation of the AC class from the 2<sup>nd</sup> grade, pupils identified a relationship between the data for the program "cartoons", by making a comparison between the choices of boys and girls:

Fabio: We mean to say that there are 5 guys here. 5 boys chose cartoons and 5 girls (pointing at the pictogram).

Teacher: Now Ricardo would like to explain this in another way. Go ahead, Ricardo.

Ricardo: In the cartoons, 5 boys is balanced with 5 girls. If we add it together, the boys and the girls is balanced.

Fabio's intervention pointed to the number of choices of boys and girls while Ricardo put forward the notion of "balance" between the number of boys and girls who had chosen cartoons. While Fabio's reading seemed to address the number of choices, Ricardo's intervention went further to identifying a relationship between these values, thus seeking to make a "reading between the data."

*Comparison of two groups of the same year.* After presenting the data from the two classes of the 2<sup>nd</sup> grade the teacher challenged pupils to look for both pictograms and compare the choices made by pupils in from those classes:

Bernardo: The soap operas in both classes are...

Teacher: Not the soap operas, the number of choices of soap operas. Go on.

Bernardo: They are the same.

Professor: More, what else is there that's more interesting in terms of comparison, Duarte.

Duarte: Sports choices are the same, in the two, sports are the same.

Teacher: How many choices for sports on the type of program?

Duarte: 6.

Teacher: 6. 3 girls in that one and 3 boys and this one...

Duarte: Only boys.

Teacher: There is only one girl. It's the same (...) What is the big difference then, in terms of choice... from one class to the other, where is the main difference? Say it.

Isabel: In cartoons.

Teacher: It's in the cartoons. We have just seen it just now in terms of comparison, right? In that class a lot of pupils chose the ... (he waits)

Pupils: Cartoons.

Teacher: Cartoons. A part from that, the other programs have more or less the same number of choices.

Isabel: It's similar.

Teacher: It's more or less the same.

Proceeding with the way in which he intended pupils to interpret the data, João continued to challenge pupils to look for "interesting" relationships. In this last episode, he used the comparison of the pictograms from both 2<sup>nd</sup> grade classes, thus allowing for the "reading beyond the data" and for the identification of common characteristics (similar) and the main difference (i.e., the number of choices of "cartoons"). João asked advanced level questions aiming to help pupils focus on the data that allowed for comparison of the two classes and interpretation of the results. He also suggested this type of analysis to compare the data of the 3<sup>rd</sup> grade. The data from his own class (3<sup>rd</sup> AC) were compared with data from the next door class (3<sup>rd</sup> BC):

Teacher: Look carefully at the two pictograms. Is there anything else in both classes in terms of choices? Isn't there anything else which is similar?

Fabio: It's the movies.

Teacher: The movies?

Duarte: And sports.

Teacher: And sports. So one class and the other class, how many bars that stand out?

Fabio: 3.

Isabel: They're the same.

Teacher: They're the same, that's it. What are the three types of programs chosen the most both in our class and the other class?

Pupils: Cartoons, movies and sports.

Teacher: Isn't that interesting? The three most chosen program types match, don't they?

Pupils: They do.

In the analysis of the pictograms from 3<sup>rd</sup> grade classes, the teacher again used advanced level questions aimed at checking for similarities between the choices of the two classes. Taking advantage of the "visual spot" of both pictograms, pupils easily identified that the three bars with the most choices corresponded to the same type of programs in both classes (cartoons, movies and sports). In the interpretation of the pictograms relating to of 4<sup>th</sup> grade classes, the teacher again challenged pupils to look closely at the pictograms, asking advanced level questions, looking for a "reading that goes beyond the data". Pupils conclude that the choices of the classes are very similar, revealing the same preferences, so any graph could represent the choices of any class.

## FINAL REMARKS

Throughout the various moments of performing the task, João attributes great importance to clarifying the procedures that pupils must take to continue their work. This concern is reflected in the preparation of data collection for the various classes, in the identification of the next steps in the task, and in preparation the conclusions.

The discussion promoted by João showed concern in engaging pupils in interpreting the data represented in the various pictograms. A representative from each group read the text with the conclusions drawn from the analysis of data from the class that he worked on and next, there was a moment for debate in which the teacher extended the discussion to the whole class. Sometimes, questions were posed to the entire group. At other times, the teacher asked the questions directly to pupils to extend the discussion and increase participation.

At first, when pupils read the written conclusions, their interventions were mostly about “reading data” available in graphs. They stated the most chosen program, adding the number of pupils associated with that choice, continuing the sequential demonstration of other choices, thus characterizing the television preferences of the class. However, even during the presentation of the findings, having been challenged by the teacher to find “interesting things”, they have established comparisons and discovered relationships between the representative values of the various categories. At this stage, the most reported aspects were related with the different choices between boys and girls and the difference between the number of choices of the several programs. Worthy of note is the emergence of the term “balanced” to characterize the similarity of choices of boys and girls or programs with the same number of choices. The intermediate level questions, allowing for comparisons and numerical relationships, contributed to the evolution in the interpretation of the pictograms from “reading data” to “reading between the data.”

Having two classes per grade, after the presentation of data from these classes, the teacher challenged pupils to “look closely” at the two pictograms, comparing the results in order to discover “interesting things”. At this stage, he used advanced level questions, trying to get pupils to “read beyond the data” (Curcio, 1989; Friel, Curcio, & Bright, 2001).

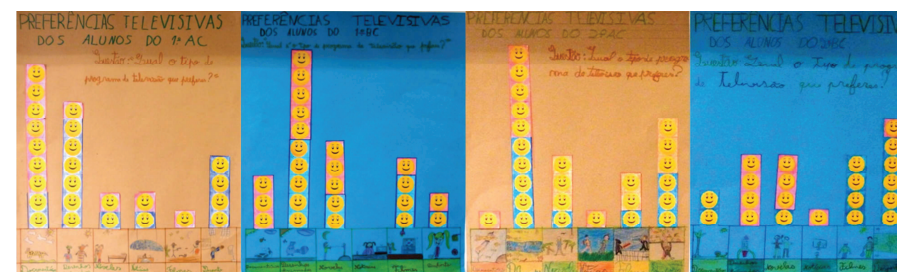
This study reveals the teacher’s role in the conduction of discussions, particularly by making questions (Friel, Curcio, & Bright, 2001). João wanted pupils not to be confined to the identification of more and less chosen programs - a characteristic from “reading data” - but tried to get them to evolve into “reading between the data” and “beyond data”. In order for this to be possible, during the discussion he asked intermediate and advanced level questions, seeking to support pupils in identifying certain relationships, or by challenging pupils to find “interesting things”.

The questioning conducted by this teacher, including questions focused on “reading between the data” and “beyond data” helped to promote the pupils’ “graphic competence”, as it is perceived by González, Espinel, and Ainley (2011).

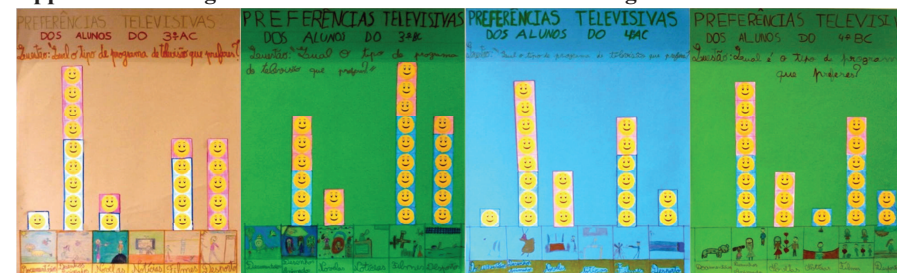
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## APPENDIX



Appendix 1: Pictograms of the classes from the 1<sup>st</sup> and 2<sup>nd</sup> grade.



Appendix 2: Pictograms of the classes from the 3<sup>rd</sup> and 4<sup>th</sup> grade.