

GRAPHS: MAKE AND UNDERSTAND

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Introduction

This study is about graphs and the methodological discussion to teach students to make and use graphs as tools and to understand Geography better. We have to teach graph as a visual language, and it is as important as a written language. Each has its own structure to give information.

Our objective was to analyze and to understand the difficulty of students (11-13 years old) to produce and to read graphs. This investigation, proposed a methodological way to improve the students skills to construct and read graphs as a tool to understand Geography as a science.

Our concern was the students. We wanted to understand their difficulties in producing and reading graphs with meaning. We thought that to investigate the problem we could not study only the students, but also their work with graphs, the qualities of graphs, and the teachers who make mediation between S - O, also had be studied.

We had to use the graphs inside the textbooks in our analyses, because in Brazil for many reasons (low salaries, bad working conditions in University Education), the textbooks are the main or in almost every case, the only material that the teachers use. It is the textbook that determines the content and the form of teaching. Thus, to understand the difficulties of teachers and students to use graphs with meaning, we have to analyze the textbook.

We studied the following 3 elements:

- 11 to 13 year old students
- the graphs inside the textbooks
- their teachers

We tried to understand how these students constructed and read graphs with real meaning, observing the forms of coordination between subject and object. To understand this coordination, we studied the subject under Piaget's theories and the object under Bertin's Neográfica theories.

This study was determined by 3 main factors:

- The difficulties of the 11-13 years old students to construct and read graphs with meaning
- The importance of producing and reading graphic representations (maps and graphs) as tools of communication in general and in particular to understand Geography as a science.
- There is little literature that discusses graphs under the NEOGRAPHICA proposal as a methodological way to teach and learn Geography.

The Subject

We chose students in this age group for our investigations because under Piaget's theories, in these ages they are passing to formal operational thought from concrete operational thought. In this process they would be able to operate graphs as a new language:

- comparing graphs with other languages that they know,
- perceiving the difference and similarity of the forms between written language and visual language,
- identifying the structure of this new language.

Both written language and graph language are tools of communication:

- give information,
- the information is organized under a structure.

But through reading graphs the subject:

- perceives the information in only one moment of perception through the synthesis,
- without ambiguity,
- having relation between the elements.

Piaget said in his theories about cognitive development of the subject that at the concrete thought age, they identify each object without relation to the other. If they have two blocks, one red and on other blue, they look at them and observe that one is red and the other is blue. But when they have developed logical mathematical thought, they can observe that the colors of two blocks are different. Therefore logical mathematical structure is important to understand that the information is the relation between the elements in the graphs.

We can put this development of the subject cognitive structure or the subject's coordination in the following synthesis (Table 1):

INTELLIGENCE STRUCTURE	POSSIBLE OPERATIONS	PRODUCTION/READING GRAPHS
Logical Mathematical Structure	Establish Relations	Perceptions of Order and Proportion
Operational Semiotic Structure	Relation between Significance and Meaning	Make Distinctions between Form and Content
Logical Mathematical Structure in Formal Operational Thought	Can Do Abstractions	Production/Reading in Proposal Stage

Table 1: Subject's Coordinations: Intelligence Structure, Possible Operations, Production/Reading Graphs (Passini, 1996)

When the subjects observe graphs better they use their cognitive structure to understand the relations between elements of information. At this stage they are able to separate content from form. When the subjects developed operational semiotic structure, they could understand that symbols have content and form. Thus this structure is important to construct and read graphs with meaning.

When the subjects could produce and read graphs making synthesis, perceive problems and propose solutions, they have developed logical mathematical structure in formal operational thought. We believe that at this stage, the subjects use graphs to understand geography better and are able to make abstractions.

The Object: Graphs and 3 Levels of Reading

Studying better the NEOGRAFICA proposal like graphic treatment of information to search for the best image, we consider that it is a good methodological way that gives the subjects the opportunity to make graphs. They cannot consider them fixed, static, defined, completed. Therefore, the students are subjects in the construction of graphs searching for an image that "talks". They have to change lines or bars N times to have effective visual communication.

We want to propose graphs as a language to communicate information alongside with other languages to understand Geography as a science. Students can look at graphs to perceive the problem in time-space relation between the elements that the graphs show. Certainly it adds to the students' conditions to understand Geography.

At the present time, we have a lot of information coming from N directions and with N possibilities to choose. Because of that, we need to understand quickly what is happening and what to do. Therefore, the graph is important because it makes the quick access of information possible.

It is important that the subjects (our students) have knowledge and skills to use this language well and can make the best choose.

On the other hand, we analyzed the graphs inside the textbooks used in the classroom. In Brazil, the textbook is the main source used for teachers that gives the content, methodological proposals, exercises, and course plans. Because of this, we analyzed only the graphs inside the textbooks. The problems of teachers and students using graphs (make, read, understand, use to perceive problems, look for solutions) is linked to the quality of graphs inside the textbooks. This quality is concerned with forms, distribution on the pages, sizes, connection with text, explanation about type of graph language and methodological orientations to read. All of above help students to understand the information inside the graphs, and helps them to improve the building of Geographic knowledge through the usage of both languages.

In our analysis of graphs we found a lot of problems. Normally, the graphs inside the textbooks do not have orientation to help students to read them. There are no explanations about the structure of this language, and they are inside the texts as illustrations only.

We can synthesize the problems that we found in the graphs of textbooks in the following scheme (Table 2):

EXTERNAL INFORMATION	ABSENCE OF KEY AND/OR TITLE
Orientation to read	Absence of explanation how to find the information Absence of explanation about structures of graphs
Form	Inadequate form: proportional data in bar graphs Sequential data in bars
Size	Inadequate size: very small Illegible
Relation between text and graph	The graph and text are not on the same page Text does not refer to graphs Content is different
Noise	There are too many symbols There is too much information

Table 2: Descriptions of Problems Found in Geography Textbooks Graphs. (Passini, 1996)

In the NEOGRAPHICA proposal we have to consider the graph dynamic:

- it is not static, completed, finished, ready,
- we have to change bars, lines, colours until we find a better image to communicate information,
- we have to read the relation between the elements in one moment of perception,
- we have synthesis when the graph is read as a whole.

Coordination Between Subject and Object

The reader of graphs has to understand its structure, finding the information where the horizontal and vertical lines cross. It is the structure of graphs, and students must read where two axes cross to get information.

LEVELS OF READING	QUESTIONS
Elementary	How many mm did it rain in January? In which month did it rain 225 mm?

Intermediary	In which months did it rain 225 mm? Which months have the highest rainfall? Which months have the lowest rainfall?
Advanced	When is the rainy season? How many seasons are there on the graph?

Table 3: The Three Levels to read Graphs

To improve through the 3 levels of reading graphs, the teachers have to give students the opportunity to have more and more contact with the object.

Studying Piaget's theories we can understand better how the coordination between S - O improve the cognitive structure of the subject. On the other hand, at putting the subject in close/deep contact with the object do that he can understand the object in their structure, creates another level of relation with the object.

The Teachers

We know empirically, in contact with elementary school teachers that they have problems using graphs (and maps) in the classroom. In the interviews, some teachers said:

- "I don't use graphs that I find in our textbook. They are complex. I never know what the lines, curves, mean ... I don't know."
- "There are a lot of symbols: numbers, lines, bars ... I never know what to do."
- "I use them. I ask the children to look at the graph and the title."

Then I asked them about classwork regarding information revealed where the two axes of the graphs cross. One teacher said:

- "Do you mean the key?"

In this interview, and in empirical observations we did not find teachers who work with graphs:

- Read them
- Work with students, producing and reading them
- Help the students to find information
- Propose to the students to change the form and choose a better form to construct graphs with an image that "talks"

Normally, the teachers whom we met, consider graphs as an illustration only, as an image without articulation between form and content.

In the circumstances in which we put graphs, teachers and students in relation to each other, we could conclude that the majority of the teachers did not know that graphs is a language, has content, and that we can change the form to look for a better image. They do not have enough knowledge about NEOGRAFICA or about the importance of this language to improve the logical thinking of students. We need to continue this study, to understand why the teachers are in this situation. We know that teachers in Brazil have low salaries and bad working conditions. Certainly, in this case, the problem is not only the working conditions of the teachers but it also concerns their University education. The majority of Geography courses do not have Cartography methodological treatment, but only a technical way to make maps. Teachers do not understand what NEOGRAFICA is.

Our Experience with 11 to 13 Year Old Students

When these students learned about the Central West Region of Brazil, we showed them a rainfall graph to introduce the climate of this region (Figure 1).

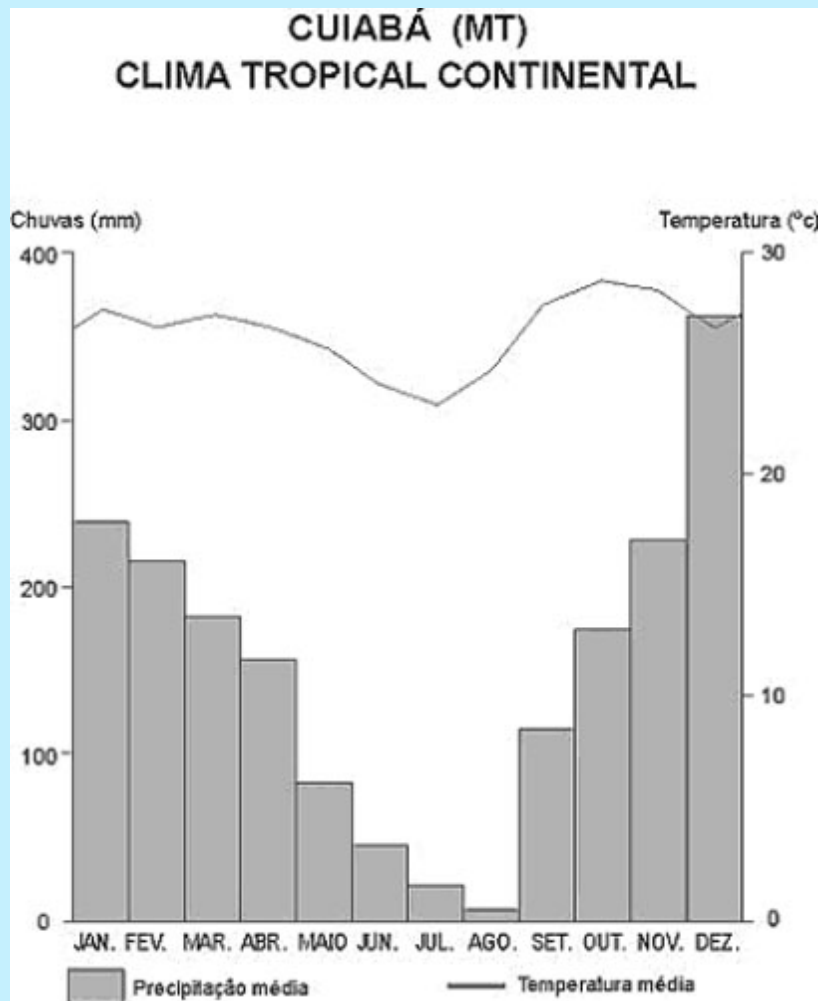


Figure 1: Rainfall graph showed to the students.

We asked them, what they could see. Their answers were very interesting (Table 4):

"I see squares" "It's beautiful" "I see numbers, letters and colours"	They only consider the form, without content
"I see a map"	They did not know the difference between a map and a graph

Table 4: Answers given to our question.

This situation showed us that they did not separate form from content, did not know that graphs is a language. Certainly they did not know what NEOGRAFICA was.

We proposed to stop the lessons about the Central West Region, and take some hours to teach them about graphs.

We asked the students to make graphs, and we said that we could make graphs of N forms and with any countable information that we had. They liked this idea, and we proposed to the class to make graphs about their ages because it was important that the information was their own.

We asked them their ages and put them in a list on the blackboard randomly. Then we organized the structure of the age graph as follows:

VER TABLA QUE FALTA EN LA CASA!!!! And the following step, we asked them to put one square on the line of their

age and on the side of their gender. They worked well, and the graph was elaborated:

VER TABLA QUE FALTA EN LA CASA!!!! They read the graph about numbers of girls and boys in each age at the elementary level. Then they could compare them and have the synthesis, trespassing to the advanced level. They put the title with proud: "Our ages".

This experience gives the students possibilities to use and produce graphs and understand that it is an alternative to written language.

After the students experience with graphs, we went back to our study of the Central West Region and its climate. We showed the graph of Cuiaba again, but this time we took out the temperature measure line and showed only the rainfall measure of the Cuiaba graph, because at this age they understand better, when we have different information separated.

When we showed this graph again, they said immediately that it was the graph that they had just looked at, and perceived that they had some information. To help them read the graph, we asked some questions:

- What does the title tell us?
- Where was the rainfall measure?

When they had some basic information, we asked more questions to help them read the points where the axes crossed. We did exercises like the following:

- Look at the horizontal line and read the months
- Look at the vertical line and read the measure of rainfall
- How many mm did it rain in May?
- When did it rain 225 mm?

Then we passed to the second level of reading:

- Where these lines cross, we have the information about measure in each month. When or in which month did we have the lowest rainfall?
- When did we have the highest rainfall?

We made some more questions to help the students to go to the advanced level to read graphs:

- How many groups can we have?
- How can we separate the months with the similar measures?

We suggested cutting the bars of the graph to put it in order and have answers to the second level: the lowest/highest measure of rainfall and then they have the synthesis (Figure 2).

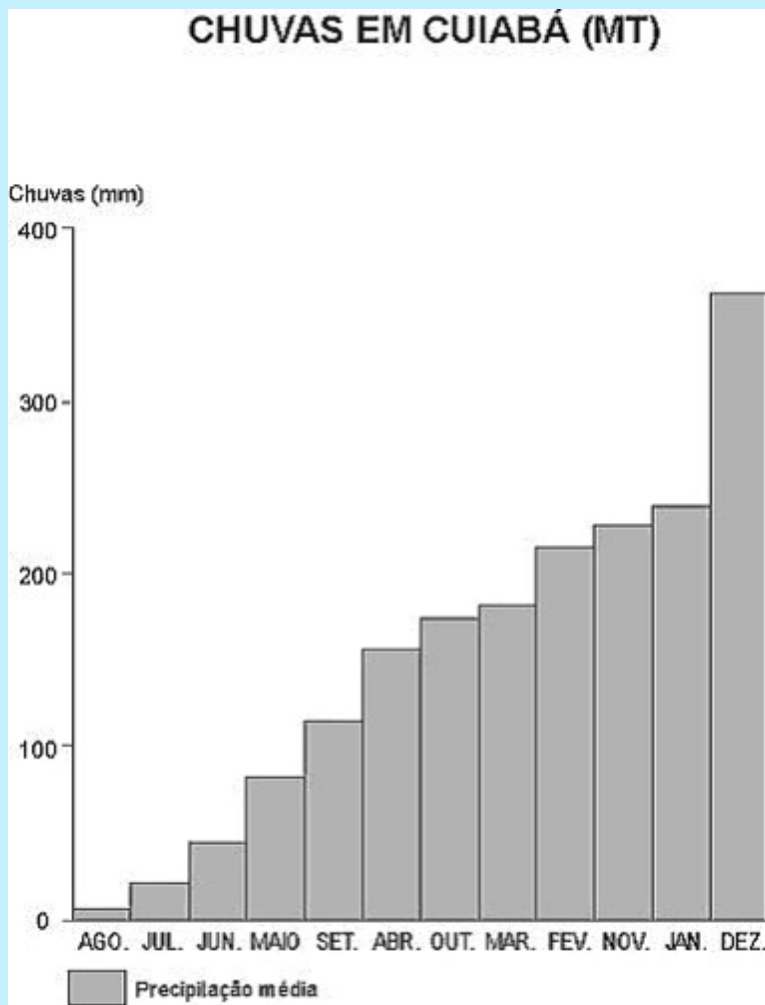


Figure 2: The same graph put in order.

We had some proposals of season's division, and we showed all proposals to the class to choose the best graph that have an image that showed in one moment the possibility to perceive the rainfall seasons (Figure 3).

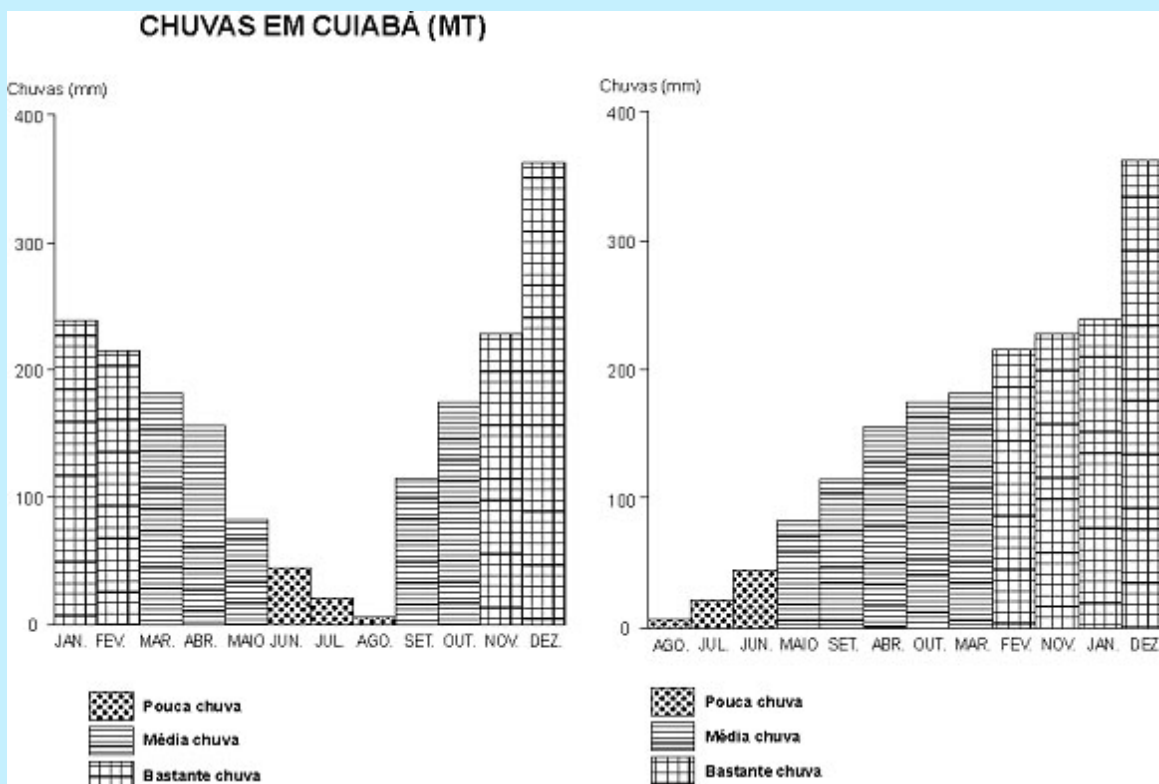


Figure 3: One of the proposals presented to the students.

Conclusions

We can synthesize our proposal to improve reading of graphs with real meaning in the following. We have to consider the subject under Piaget's theories to help students to use graphs as a tool, using their constructed knowledge and with coordination between them and the graph. In this coordination the students advanced from lesser to greater knowledge.

The teacher has to give opportunity to students have coordination between them and the graphs. We have to teach the methodological proposal under Piaget and Bertin to elementary school teachers because they have problems in this field of knowledge.

We have to analyze graphs inside the textbooks to propose improvements in order to have:

- correct graphs on the perspective of graphical semiology theory,
- orientation to help students to search for information using graph structures,
- better articulation and coherence between form and content,
- coherence between content of all languages used: texts, photos, maps and graphs.
- adequate position of graphs on the page
- adequate size to be able to read

We hope to have suggestions from researchers in this area to evaluate if using graphs as language the students are able to understand Geography better and use it as a science and understand the world.

We believe that if you can read graphs at the 3rd level, you can perceive problems, understand Geography as a science and have the ability to propose solutions.

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