INVESTIGATING THE INTERPRETATION OF ECONOMICS GRAPHS[1]

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Several studies in cognitive psychology have investigated the development of mathematical knowledge in cultural practices. For example, some authors have investigated situations where people deal with economic issues, which refer to quantitative relations and mathematical concepts. Print media use graphs to give information about economic topics, e.g., variations of the rates in inflation, and wages. This study investigates the ways in which economists and business people, who subscribe to magazines and newspapers, interpret such graphs dealing with economics. The aim of the study was to identify how the background of the interviewees and the specific aspects of the graphs influenced the interpretative situation. Analysis of the data raised issues related to the teaching of graphing.

INTRODUCTION

Several research studies in cognitive psychology have investigated the development of mathematical knowledge in daily professional activities (Schliemann, 1995). Generally speaking, three aspects could be noted in the majority of those studies. First of all, the participants have limited school experience. Secondly, those studies approach specific mathematical concepts and procedures (e.g., arithmetical operations, area calculation, etc). Finally, these studies indicate that subjects competently solve mathematical problems in their work practices.

Similarly, this paper reports a study that investigated cognitive processes pertaining to the utilization of mathematical knowledge among professionals in an everyday activity. However, in contrast to the studies described above this paper approaches a topic that has been little explored within the Psychology of Mathematical Education: the interpretation of graphs in print media. In addition, the present study investigated the activity of interpretation among professionals with high levels of schooling.

Carraher, Schliemann & Nemirovsky (1995) argue that individuals with limited school experience do not have a general difficulty in working with symbolic representations because everyone uses symbols whenever they think and communicate. On the one hand, these authors remark that in interpretative situations a graph could be defined as an instrument to express the ideas of the person who interprets it. On the other hand, they acknowledge that a person with a limited schooling level would not work out all the issues involved in a graph.

In the light of such discussions, this paper investigates how individuals with specialized competence could interpret media graphs. Would their interpretations be refined? Could professionals with a background in the utilization of graphs realize a more complete interpretative approach?

THE INTERPRETATION OF PRINT MEDIA'S GRAPHS

Even in the 'strict sense', the word 'interpretation' means more than the perception of information. The interpretation of graphs is not an isolated activity. It should be considered as part of a Data Handling process that is a human activity in which people can explore information and construct knowledge.

Therefore, interpretation is more complex than observation. The person needs to make relationship between data and needs to make inferences about the information (Shaughnessy et al., 1996).

Referring to the relations between data and people, Gal (forthcoming) differentiates two kinds of context. When people read newspapers or watch TV, they should be called 'data consumers'. On the other hand, when they interpret and report their own findings and conclusions, they could be denominated 'data producers'. In spite of this differentiation, a same person might be consumer and/or producer, depending on his/her context.

The context of use of graphs is an important aspect in understanding interpretative processes. For example, readers of print media and students in the classroom have qualitatively different contexts for the interpretation of graphs. Consequently, different meanings could be attributed to interpretation when it involves specific participants and particular settings.

In contemporary society, graphs are frequently used as sources of information in the news media. In this context, the graphs illustrate journalistic arguments for different topics, and could emphasize and/or disguise data (Meira, 1997; Ainley, 2000).
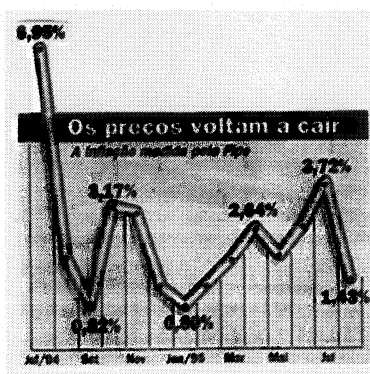

Figure 1: graph reprinted from a Brazilian weekly magazine.

Figure 1 provides an example of a media graph that was published in a report about the consequences of Real Plan (Brazilian government's current economic policy). The title is: *"Prices have fallen again; Inflation measured by FIPE"* (Economics Research Foundation in Brazil). The graph displays information related to a period of 14 months, but it presents just 7 indices that correspond to peaks and troughs. The choices of figures presented and the omission of some months labelled were deliberately used to emphasise the main theme of report.
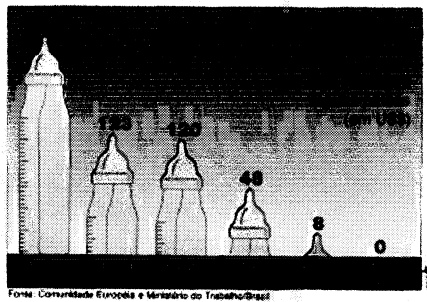

Figure 2: graph reprinted from a Brazilian weekly magazine: "the value of children: monthly benefits for two children in some countries (US$)".

Another example of a media graph is shown in Figure 2. On the top of the 'feeding bottles' there are figures for each country, and on the bottom there are the names of countries. Belgium's bar is a complete feeding bottle. The graph presents partial pictures, which symbolize France, Germany, and Italy. Brazil's value is just shown through the feeding bottle's tip. Finally, there is not any piece of a picture for United States' zero value.

The feeding bottles used in graph were 'adornments' used to illustrate the topic (Meira, 1997). On the one hand, those visual resources could be a distraction from the interpretation process. On the other hand, the feeding bottles, as extra-mathematical components, might be a symbolic source related to "the value of children".

In the following sections we present the design, results, analyses and conclusions of a study which investigated the processes of interpretation of such media graphs among specialised professionals. This study aimed specifically to explore how the interpretations of media graphs could be influenced by specialized background of readers.

ECONOMISTS AND BUSINESS PEOPLE INTERPRETING GRAPHS

The final research design of this study was based on the analyses of pilot interviews with several professionals (e.g. secondary school teachers, engineers, researchers). The analyses of pilot interviews mainly provide reflections about the relationship between the background of interviewees and their familiarity with the theme of graph. We decided to focus on economic topics because these were frequently shown

in the media. The economic theme was also very important during the period of data collect, because recently Brazil had moved from high inflation levels after a governmental economic plan.

Among several specialized professions related to economics issues we chose research economists and businessmen/women. The economists have a 'data producer' routine, which include production, analysis and reporting of economics data. Those economists frequently construct, use and interpret graphs. The businessmen/women also produce and analyse data related to their work. However, rarely they construct and use graphs in their work routines.

Two groups of eight interviewees were formed. All participants were daily readers of print media, and subscribed to at least one newspaper and one magazine. Therefore, all of them were 'data consumers'. In addition to specific professional routines, these groups were differentiated by academic background and age (See Table 1).

Groups Averages	Age	Years after of first degree	Postgraduate courses
Businessmen/women	37	13 (different courses)	12,5%
Economists	47	23 (economics)	100%

Table 1: Background of two research groups.

Each participant interpreted seven graphs, which were published by two national magazines and one local newspaper. This paper only refers to data from two graphs (see Figures 1 and 2).

In interview, two types of questions were asked. The questions called 'general' were asked at the beginning and at the end. After of first question, the researcher asked more specific questions, which attempted to investigate interviewees' understanding related to particular aspects of each graph presented.

ANALYSIS OF INTERVIEWS

The interpretations related to the first general question were called 'initial approaches', and the answers resulting from other questions were called 'specific approaches'.

Initial approaches

The analyses of 'initial approaches' demonstrated that there was a tendency towards discursive and extensive comments. We could distinguish three categories of 'initial approaches'. The first one was characterised by comments which related to data that came from the graph. The majority of interviewees demonstrated this kind of strategy (59%). The following exchange is an example of this category:

Researcher: What could you notice from the reading of this graph? [See figure 2]

Businesswoman: [after reading the title, subtitle and labels] It is in dollar. Isn't it? ... Right... It means that in the United States... Here there isn't any benefit for two children!

Researcher: The graphs shows that, isn't it?

Businesswoman: It is... At least... I don't know if I am wrongly interpreting. [Reread the title]... It is for two children, it is not for one, either for three. For two... [Reread the names of countries and corresponding figures]... I didn't really know this aspect!

In her initial approach, the Businesswoman tried to establish relations between the data shown by the graph. We can note that her surprise at values for the United States provoked a rereading of the graph.

Another type of discursive strategy was characterized by interviewees talking extensively about the theme, but basing their analyses on their previous knowledge and experiences rather than on quantitative information presented in the graph. Approximately one quarter of the interviewees (26%) were placed in this category.

A third type of strategy identified was that interviewees approached the quantitative information more directly. They made approximations and estimates, and/or they made written calculations and used calculators. The frequency of these strategies was low in 'initial approaches' (15%). The following extract shows an example, in which the interviewee utilized a formula to compare the relations between the values of benefits in each country in figure 2.

Researcher: What could you notice from the reading of this graph?

Economist: ...Have you cut something here? Because this graph is not explicative (...) I understand that (...) the benefits in France, Germany, Belgium, and Italy, are very, very much higher than the benefits in Brazil. In the United States there is not benefits [for children]. You can realize the following calculation [using a calculator, talking aloud] 222 ÷ 8 = 2775%. It means that the benefits in Belgium are 2275% more than the benefits in Brazil. Or the benefits in Belgium are 28.7 times higher than in Brazil. The benefits in Italy are 6 times higher than in Brazil.

His procedure provided a more accurate approach to the quantitative information from the graph. Afterwards, he explained his strategy that could be represented by following expression:

$$\frac{\text{Higher value} - \text{Least value}}{\text{Least value}} = W \times 100 = \text{comparative percentage}$$

Specific Approaches

The analyses of interviewees' answers to specific questions only generated two categories: comments from the graphs' data (50%), and approximations and estimations, and/or written calculations (50%).

However, the analyses of frequencies of interpretations developed from each specific question revealed particular tendencies. For instance, all the interviewees utilized the

strategy 'comments' to answer the question: 'what would the number 8 mean?'(Figure 2).

Researcher: What would the number 8 mean?

Businesswoman: So... The benefit would be for one child? But, here it is US$8, isn't it? It shows US$8, but this value is an average, isn't it? Because, I know that on the commercial sector [my] the employees earn 7.5 per each child [she referred to Brazilian money = Reais]. It is very few!

Researcher: On the commercial sector is?

Businesswoman: On the commercial sector are 7.60 [Reais] per child. Here, it is showed US$8 per two children, isn't it? ...Per two children. I also think that it is the average of all the professions. I have heard that they really pay very well (referring to European countries).

The Businesswoman drew on her experiences as employer, and her general knowledge about social policies, when she was answering the specific question. In spite of these references to her expectations about the figures, she analysed the data from graph.

In contrast to the frequency of answers from the benefits' question, nobody developed extensive comments from the inflation's question: 'Which period had the faster speed of increase of inflation, in Jan-April/1995 or in May-July/1995?' (Figure 1). The analyses of protocols indicated that all interviewees answered through approximations and estimative, and/or calculations. The following extract gives an example this strategy.

Researcher: If we will compare these two peaks [Jan-April/1995 and May-July/1995], which is the faster increase?

Businessman: Well... If I will trust the drawing... Because it does not have number for that I can calculate [Referring to May of 1995]... Is that from May to July? Its inclination is bigger!

Researcher: If will you trust the drawing?

Businessman: Well... Looking to the drawing... It depends on... Would you like to know how much increasing between here and there? [Referring to May-July/1995] Or would you like to know the inclination?

Researcher: The speed.

Businessman: The speed here is bigger [May-July/1995].

Researcher: Do you see it just because the inclination?

Businessman – Exactly! I know that the speed is derived to the distance here. Then you look to the inclination to know what is more quickly increasing.

The Businessman's approach was more strictly related to the data from the graph. His calculations were associated with specific features from the graph.

This specific question had some peculiarities. Firstly, the question asked was connected with the comparison between two periods. In general, the other questions involved comparing two particular values. Secondly, the graph did not present all the numerical values for the calculation asked. The interviewee had to estimate the percentage of May/1995. Thirdly, the concept of speed could not be applied for percentage values of inflation. The suitable procedure should be the comparison between the average increasing percentages on each period. But, this calculation was not possible because the graph did not present all monthly percentages.

We researched the real values in each month displayed by the inflation graph, and we found that the period of highest increasing was between May and July of 1995. In spite of the absence of all necessary numerical values, 25% of interviewees correctly answered the question. But, the more frequent answer was the period between January and April (44%).

The variability of specific questions and of the levels of complexity could be possible causes of particular tendencies of interpretation of interviewees. It could be argued that the specific question related to the benefit graph was more open than the specific question for the inflation graph. This argument might be simplistic, because, for example, the same structure of question was used with the interviewees when they were interpreting another economics graph. In that case, 31% of the interviewees made strategies of approximations, and estimative. Thus, we believe that the analysis of the whole body of data is important to understand these particular results in specific questions.

A second cause could be connected with the type of graph: the benefits graph might be simpler than the inflation graph, partly because it presents 'adornments' that could make it most accessible. However, our analyses did not show any relation between pictures shown and 'facilities' or 'distractions'. In general, the feeding bottles were an initial attraction, but that it did not 'help' or 'confuse' the interpretation process.

On the contrary, real interpretation could be more difficult for the benefits graph than for the inflation graph because it requires the reader to know other information related to several areas. When the researcher asked about the necessity of other data, the majority of the interviewees affirmed that this was necessary, for example to know something about the cost of living in each country.

CONCLUSIONS

Our initial hypothesis was that familiarity with the use of graphs and academic background could be important elements which would influence the interpretations. However, analysis of the data collected from the whole study does not show any particular patterns suggesting differences between the two groups of interviewees in the ways that they interpreted the graphs.

Firstly, we could emphasis that the familiarity with the theme of graphs is not itself a facilitative aspect. The familiarity needs to be immersed in meaningful relationships

between the interpreter and the graph. In other words, the importance of familiarity is not a pre-established aspect that independently happens.

Secondly, the academic qualification of the interviewees is one part of their background. The economists and businessmen/women are also citizens, consumers, fathers and mothers, electors and so on. From multi-background, interviewees brought their believes, desires, and knowledge about everyday situations to their interpretation. Therefore, the interpretation of graphs demands more than a specific competence for perception of information.

On the other hand, we could remark that the generic mobilisation of knowledge is not enough. Even 'data producers' like economists also need to engage in a context, in which the mathematical relationships could become explicit. In our study, the specific questions prompted the interviewees to approach the graphs in more detail, becoming aware of the mathematical relations involved. For example, our analyses demonstrate that specific questions provoked a decrease in generic approaches.

In the contemporary society, the school is a context in which processes of teaching and learning related to graphs are developed. Specifically from our data analysis, we may infer that it is important to consider the planning of didactic sequences with graphs, which provide the mobilisation several types of knowledge, and that construct bridges between previous experiences and the formal aspects of mathematics present in graphs.

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