SECONDARY SCHOOL MATH TEACHERS' CONCEPTIONS OF THE STATISTICAL GRAPHICS' FUNCTIONS, READING AND INTERPRETATION

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The importance of statistical graphics, as well as their practical use in day-to-day scientific research, makes it worth assessing and appraising teachers' conceptions concerning this matter. Accordingly, we should shed some light on the most specific components of dealing with such graphics as understood by math secondary level teachers. At the end, we try to give some guidelines that could be useful when elaborating on a content for teachers' training.

INTRODUCTION

Two essential factors are behind the interest that we grant to the statistical graphics and to secondary level math's teachers' conceptions concerning the functions of this kind of graphics, as well as to their reading and interpretation. The first component concerns the increasing importance of such diagrams. Indeed, on the one hand, they constitute a particular type of diagram, since they are distinguished from others by the situations they represent, the principles of their construction as well as the kind of reasoning they generate. On the other hand, they are omnipresent in different scientific fields and in different matters of teaching. Finally, they are frequently met in the real society, via newspapers, magazines and other publications.

The second factor has to do with the importance we grant to the teaching of this kind of graphics, and to their mastering by the teachers. In fact, some research results showed that they constitute one of the main tools of statistical reasoning. Indeed, MacGregor & Slodvic (1986), showed that some statistical graphics, such as stargraphs or Chernoff faces generate and facilitate statistical judgments and evaluations better than some others. Also, they permit to approach the statistical subject holistically, by representing actual data, while showing its utility and its object. Thus, making it more palpable and more accessible to pupils.

Besides, due to the fact of introducing computers in high schools, interpretation of graphs becomes more urgent than their construction, and so constitutes a main objective of their teaching. Finally, statistical books and manuals are rarely concerned with the features, the functions and the interpretation of these graphics. Envisaging a teaching that focuses more on the analysis of these graphs as well as their exploitation leads us to questions regarding the preparation of teachers for this type of objective. In fact, it's a teaching mainly based on activities that enhance the ability to construct these graphs and to understand their components as well as their features and functions. Are our teachers well trained in statistics? Are they initiated to the general principles of graphical science? Are they capable of preparing their pupils for the statistical diagram interpretation and to construct concomitant situations? What are their own conceptions of these graphs, their functions, their reading and interpretation?

RESEARCH OBJECTIVE AND QUESTIONS

To further tackle these questions, we addressed a questionnaire to 61 secondary level math's teachers, in an attempt to gauge their conceptions concerning the objectives of teaching statistical graphics, their teaching and learning difficulties, and finally, the way they exploit them in class. The results of this investigation showed that the activity of construction outweighs that of interpretation. The latter seems to be too scarce. Difficulties associated with the former are more specified than those associated to the latter. Added to that, no definition of reading or interpretation has been provided by the individuals.

It is assumed that this very fact could have some serious implications on the level of teachers' knowledge concerning the statistical graphics and their exploitation, along with a lack of information on features of these graphics, their functions and their relations with statistical reasoning. Hence comes the need for identifying aspects and reasons for this problem.

Our literature review included works on graphic classification and understanding, on difficulties of their interpretation, as well as of works on their historical evolution and their

teaching and learning. It permitted us to better specify the meaning of the terminology used (reading, interpretation, Statistical Reasoning, difficulty), to elaborate a model of understanding of the concerned graphics, which is useful to analyze them. And finally, it made it possible to clear the historical evolution of their functions, and to deepen our research objective and our questions. These are formulated as follows:

Objective: Identify the concept and functions that secondary level math's teachers associate with the statistical graphics, and to know about their reactions to the reading and the interpretation of those graphics. How do they perceive these graphs? Which functions do they associate with them? Which significance do they give to their "reading" and their "interpretation"? Which distinction do they make between these two operations?

RESEARCH METHODOLOGY

To reach this objective, we relied on a questionnaire and a set of interviews. The questionnaire constituted of five parts (general information concerning teachers, statistical object, graphs' functions, definition of their reading and their interpretation). The interviews are devised to compound the results yielded through the questionnaire.

POPULATION

Our sample constituted 221 secondary level math's teachers, spread on different Moroccan cities. The fifteen interviews we did, stem essentially from teachers' voluntary work.

METHODS OF DATA ANALYSIS

For results of the questionnaire, we used a multiple correspondence analysis (MCA) for each of the last four parts of the questionnaire. Some questions of the first part are used as supplementary variables. Regarding the results of the interviews, we opted for a qualitative analysis, aiming to classify the ideas and answers of teachers.

RESULTS AND ANALYSIS

These results come, on the one hand, from the different factorial analyses, that are carried out, and on the other hand, from the interviews analysis. In both cases, they carry on the last four components of the questionnaire. In the following, we present results concerning the statistical graphics' functions, their reading and their interpretation.

a) Results concerning statistical graphics' functions. Concerning these functions, the factorial analysis displays clearly different conceptions, fairly represented by the individuals.

Formal/calculatory conception. It links these functions with the determination and calculation of the statistical parameters. Thus, limiting itself to the formal and calculatory aspects of statistics. This conception tends to be complementary to the one brought by the interviews, which consider statistical graphics as curves of functions, eliminating namely its statistical aspect (the represented statistical concepts, the sample, the shape of the statistical distribution …) keeping only the analytic ones (variations, the minimum or the maximum). Let's note the fact that without taking account of the context of the situation represented, this conception doesn't stimulate any statistical reasoning from the graph.

Synthetic conception. It considers the graph as a summary of data and relates its functions to their synthesis, summary and approximation. It supposes a loss of information, but not inevitably an inference or a modeling. The results of the interviews confirm this conception as well as the functions that ensue.

Predictive conception. This conception attributes to the graph a function of inference, but deprives it of its functions of simplification and description, presenting an analogy with the one that limits the statistical object to forecasting. Individuals associated with this conception manifest a lack concerning the statistical instruction or the practice of the teaching of this subject matter.

Visual/ static conception. This conception allocates to the graph the function of showing the visible features of the studied phenomenon. It includes the descriptive aspects as well as the inferential ones, but without taking into account the principles and the heuristics of the statistical reasoning. This conception is confirmed by the one, brought by the interviews, which perceives

the graph as a picture, that reproduces data without any loss of information, thereby limiting the functions of the diagram to visualization and communication. In fact, the iconic and static aspects detach the diagram from its faculties of conjecture, modeling and inference, without which the loss of information is completely concealed, and senseless.

Our results revealed another element behind the difficulty to perceive the loss of information correctly, linked to some graphs. This loss is not bound to some susceptible notions such as "classes", "frequency" or "distribution", which generate the fact of loosing information. In other terms, the simplifying tendency and the modeling aspect that make the wealth of certain graphics, such as the histogram, don't constitute a common knowledge for these individuals.

b) Results concerning the reading of a statistical graphic. Concerning the definition of reading statistical graphics, several conceptions are revealed. A very general one links it either to the verbal translation of data represented by the diagram, or to the extraction of all the information that one can deduce from the diagram. According to another conception, to read a statistical graphic is to gather global order information (such as deducting variations). Therefrom it translates a confusion of reading and interpreting. Finally, we noted a conception that tends to rejoin our definition of reading. This one comes back to decode the content of the diagram, by raising the represented information or identifying the represented statistical variables.

Aside from the last one, all the other conceptions of reading a statistical graphic, come down to the fact that they don't distinguish, neither between the information having a global aspect and those having a local one, nor between those bound to the context and those abstractly expressed. They are confused with what we defined as the interpretation of a statistical graphic.

c) Results concerning the interpretation of a statistical graphic. Concerning the definition of the interpretation of statistical graphics, the analysis of the factorial plans shows three different conceptions.

Predictive conception. With respect to the first one, the interpretation is associated with inferential operations such as estimation and forecasting, but not with descriptive operations. This conception is sensed especially in individuals manifesting an absence of practical teaching of statistics.

Descriptive conception. The second conception has a reversed tendency. It associates the interpretation to some descriptive aspects, such as describing variations or comparing the data.

Stochastic conception. The last conception associates the interpretation with descriptive and inferential operations as well as the extraction and the comparison of general order observations. Thus giving a more general sense of interpretation. Individuals having this conception are BA holders or "aggregés", who have an academic instruction in statistics.

The interviews' results, confirm and complete those of the factorial analyses. They show some relations between the different ways of defining these two operations. Indeed, reading considered as raising what is directly legible from the graphic, is bound to interpretation, either as the "effectifs'" translation in frequencies or in percentages and their comparison, either as the explanation of the meaning of these "effectifs", or as a decision making. Whereas reading brought back to the calculation of statistical parameters, is related to interpretation giving significance to the resulting values. By specifying the parameters, this definition sets aside the interpretation of the graphic, which can carry on the shape of the distribution, on the extricated values, on the ensued comparisons and the model to which the data can be adjusted.

Although the idea of distribution symmetry has occasionally been raised in a direct or indirect way, the average calculation was not related to it. Apart from the "mode", all parameter calculations are formula bound. We conclude that there is no correspondence between the shape of the distribution and the average value or its position in relation to the "mode", in the case of a unimodal distribution.

RECOMMENDATIONS

This research highlights some erroneous or incomplete conceptions of the statistical object, the statistical graphics' functions and the definition of their reading and their interpretation, as held by the secondary school math's teachers. These conceptions generate difficulties having to do with statistical concepts understanding, features of different graphics and

their relation with statistical reasoning, usefulness of these graphics in resolving some statistical problems, their reading and their interpretation.

To tackle such difficulties, it is recommended that statistics training should be conducted. Its primary focus should be on epistemological and didactical analysis consisting of heuristic aspects and meaning questions, with respect to statistical knowledge and more specifically, its applications. A good deal of importance must be allowed to concept analysis, to statistical tools and applications. It must join the theoretical aspects to practice and show the range of different aspects of use, such as data organization and summary, graphical representation, and the different utilizations as forecasting, estimation, decision making, sampling, analysis of chronological series, multi-dimensional analysis.

It should also insist on statistical applications to different domains such as demography, economy and medicine. Thus emphasizing the question of conceptual meaning. We think that the interpretation of the statistical concepts and parameters are the best means to achieve this objective. We also think that a lot of importance must be granted to the survey of statistical graphics, their analysis, their exploitation (highlighting their functions), and to their reading and interpretation.

REFERENCES

MacGregor & Slodvic, (1986). Graphic representation of judgmental information. *Human Computer /nteraction, 2*, 179-200.