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EDUCATIONAL HYPERTEXT IN THE TEACHING OF STATISTICS: A POSSIBLE USE FOR AN INSTRUCTION MODULE FOR THE ANALYSIS OF THE RELATIONS BETWEEN TWO VARIABLES

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1. The hypertext as guide and conditioning: why use it in teaching?

The common definition of a hypertext is that it is a non-linear text or a collection of information arranged on a computer in such a way that access to it need not necessarily be of a sequential type. The information may actually be contained in texts or it may be in the form of graphic or photographic images, animations, films or sound recordings. Using special software the information is then included in files, whose consultation/reading is tied to graphic objects such as buttons, fields, windows, icons, etc. that allow interaction with other data or information on file (Corcione and Di Tonto, 1990; Barret, 1989).

Another definition of hypertext, which is suited to its use in an educational context, is that it is essentially a virtual text, i.e. a text in which the information does not have its own intrinsic ordered structure. In a hypertext, the information has only a virtual order, i.e. an order given by the possibility that the reader has to navigate from one anchor to another, passing through the nodes provided (the key pieces provided in the base structure). It is said, therefore, that particularly in the field of education the hypertext is a class of possible texts, generally very wide, but strictly determined, one of the members of which only becomes actual at the moment of reading. More precisely, each member of this class of texts becomes actual only through the operation of reading/consultation on the part of the user. Otherwise the member remains existent only virtually. It appears clear, moreover, that this virtual form of the organised

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[1] The paper is the result of the collaborative research of the two authors. F. Camillo wrote this paper and helped to construct the demonstration hypertext *BivarZero*.
[2] M. Pedroni contributed to the writing of section 3 and composed *BivarZero* in Toolbook.

information can exist only on the computer. Every print-out and every reading must necessarily be actualised, that is made concrete, by a particular request or instance (Antinucci, 1991).

The cognitive instance by which the user moves with respect to the hypertext thus represents the determining cause of the system of options and paths that this same user will follow from time to time. The choice of one path rather than another thus depends on the modes of perception of external stimuli (perturbations) that the subject normally adopts every day in the three phases of information processing: perception, signification and memorisation (Rondot, 1993).

In educational hypertexts, as in every other didactic tool, perception and memorisation are influenced by the sensibility and experience of the author. The author, however, inevitably loses a part of his or her authority over the hypertextual work, to cede it to the reader/user. It is the latter, in fact, who constructs step by step the fruition process, and hence the learning steps (Antinucci, 1991). Finally, in learning from a hypertext, signification is generally stimulated and directed by the author through the definition of the architecture of the whole hypertext, i.e. by the structure of nodes and links laid down *a priori*.

With regard to the possible didactic functionality of hypertexts, it has recently been emphasised that they must not be seen only as a new form of author system, able perhaps to produce courseware of a new type or global self-teaching environments. Rather, they must be considered also as an important tool for the arrangement and subsequent fruition of didactic materials and contents within a broader, more complete educational process (Varisco, 1991).

In company and professional environments, in particular, there are already numerous examples of hypertexts acting as didactic tools for reviewing or arranging knowledge, especially in the fields of technology and engineering, history and literature, architecture and design. In these cases, the hypertext allows the user to review and to investigate a vast collection of cognitive materials, linked together at the level of the company or professional courseware, which is constructed by the user himself (through the paths and options chosen) according to the particular needs of the moment or the particular problem that has arisen in the everyday productive sphere.

2. Why use the hypertext in teaching statistics? How to interpret the guide and the conditioning

The general background to which we have referred in our introduction

to the hypertext is fairly traditional and commonly accepted among experts and scholars in the field. The use of hypertexts in the teaching of statistics, which is the subject of the remainder of this paper, is thus not of itself innovatory, except in terms of the context, the motivations and the purposes that have encouraged and directed our research.

One of the many definitions of Statistics says that it is "... the quantitative analysis of the observations of any phenomenon subject to variation, that is of a variable; objects for analysis are therefore all those phenomena which are subject to change..." (Naddeo, 1984).

Statistics is thus a vast subject, multiform in its subjects and open to innumerable approaches in the resolution of problems concerning the analysis of observations. Moreover, given the proliferation at every level of data and information collection processes, Statistics is used increasingly in fields that do not strictly belong to the statistician, and where it is increasingly considered as a tool for measuring and analysing the relations that exist between phenomena that are very much of a day-to-day operational nature.

In the light of these premises and of the above interpretation of the hypertext as a text that exists only in virtual form, it would seem to us that hypertexts may aid the learning and use of statistics by means of three fundamental kinds of intervention:

1) systematising, in a single large connected system, the strategies of analysis, research methodologies and techniques that make up Statistics;
2) providing the user of Statistics with a tool which directs him to the solutions of specific problems, but which allows him at any moment to construct his own map of statistical knowledge prior to the comprehension of the strategy itself (e.g., the necessary mathematical formalisations of the problems);
3) constructing an informatic environment that makes it possible to provoke a set of important cognitive perturbations in the learner. In particular, this means provoking perturbations that induce the user to turn directly towards the solution of the problems of analysis and which, through graphic and sound interaction, stimulate his intuitive ability to verify the solution identified, even before the learner possesses the necessary formal tools.

The links between the various parts of Statistics and between these and other disciplines could also represent a system of links of a sort of hypertextual *opera omnia* on Statistics about which it is difficult even to make hypotheses at the present stage.

There is no doubt that the hypertextual tool permits us to explain a complex multilevel, multipurpose and multidimensional structure like

that which exists in the field of statistics education. Furthermore, for didactic purposes, it allows us to move users through the various areas of statistical knowledge by conditioning them to intuitive stimuli and directing them in their choice of paths. Particular attention must be paid, however, when planning a hypertextual statistics module. Navigation between the nodes and the anchor must be easy and, above all, there must be no danger of losing one's way in the intermediate cognitive charts with respect to a specific targeted path. Therefore, it is necessary to provide an easy return to the main path (relating to the specific statistical problem) from those propaedeutic formalisation/clarification charts relating to any problem the user may have opened up.

3. The module constructed (*BivarZero*): an experiment for concrete problems

The hypertext that we have constructed up to now represents only a first experiment. The *BivarZero* module concerns the problem of measuring and analysing the relation between two variables[3]. The spirit with which it was designed corresponds to what was said above in points 2) and 3), namely to the criteria of the strong applicability/operativeness of the solutions and to the intuitive characteristics of the user's choice of the best statistical solutions. Thus, the module created may be considered as a prototype for a larger courseware aimed at users interested in the application and operation of Statistics. The environment within which it was constructed is ToolBook 1.5 for Windows 3.0 for Personal Computer.

As Fig. 1 shows, the architecture of the hypertext is strongly interactive. It places the user in the position of a statistician, or at any rate of a user already trained in statistical methods. Learners are required to put their intuitions to full use. Users are introduced immediately to the particular problem that create for themselves and which they recognise and classifiy in the *BivarZero* initiation structure. The general sequence is strictly oriented towards the statistical solutions to the three possible problems that the user may encounter:

1. analysis of the relations between two quantitative variables;
2. analysis of the relations between two qualitative variables;

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[3] *BivarZero* means that we are dealing with a prototype module (module 0) that tackles the measurement and analysis of bivariate dependence only for the purposes of demonstration. The experiment presented here concerns, in particular, the area of action relative to the dependence between two quantitative variables.

3. analysis of the relations between one qualitative and one quantitative variable.

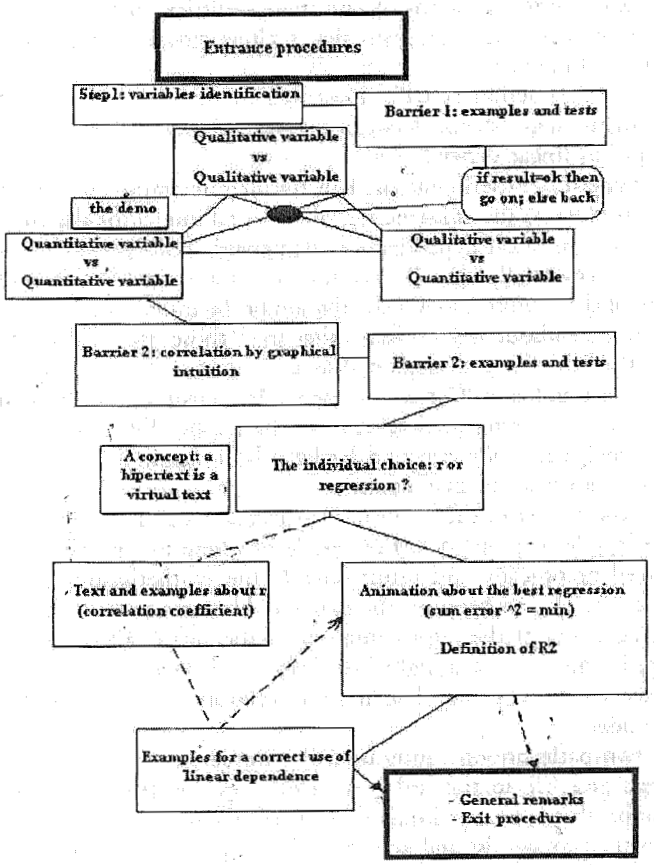

Figure 1. *The Hypertext Map and BivarZero journey*

In the introductory step, users are invited to pose their own concrete cognitive problem in a precise space of action. This involves the recognition of their problem in one of the three types of relation provided, by arranging the available information in the context of the measurement scales for the variables (Leti, 1983).

At this point, the path is directed by the classification tests that are applied to the concrete problem, but the connections among the three areas of action are many, and in any case the treatment of the basic subjects is common to all three. The subjects considered as basic are anchored to key words and comprise questions of univariate statistics, such as position and variability indices, and of mathematics, such as certain notions of analytic geometry and derivation.

The space of action actually presented in this demonstration is that relating to the dependence between two quantitative variables, and more specifically to linear dependency.

The hypertext experiment used in the demonstration was devised by guiding the user to the construction of a mental model for the correct use of the notion of linear dependence. The perturbations preliminary to this subject are essentially visual, and aim to arouse the graphic-geometric intuition of the subject (visual perturbation of the intuition).

The user, without any notions other than those provided in the path through the initial step, is requested to associate four forms of dependence to the same number of Cartesian graphs. Any error in this association is explained by a learning path relating to the reasons for this error, which involves navigation sideways and backwards along the basic concepts of univariate statistics and mathematics.

Once the barrier of the intuition perturbation step has been overcome, the user is able to proceed to the next level where two possible paths are introduced graphically and intuitively: 1) the synthetic measurement of the linear correlation between the two variables using the r coefficient of Bravais-Pearson; 2) the approximation of the relation between the two variables by means of a straight line, leading on to the estimation of the parameters of the regression line and the verification of the hypothesis of a linear model.

The two paths are obviously linked at numerous points and it is thus that users give life to the real text themselves: i.e. from a collection of information that is arranged only in a virtual manner into a text, the reader becomes the protagonist and actuator of the hypertext. The path actuated is clearly a function of the specific aim of the user and of the type of signification that he has given to the visual perturbations received in the previous step.

In a hypertext strongly directed to the solution of a specific problem such as the *BivarZero* experiment, it seemed very important to prepare a "help" image that allows the user at any moment to solve any problems of confusion or loss of way conected to the exploration of the intermediate levels or of the information base.

Our illustration of the potential of the *BivarZero* experiment loses

much if it is presented in the form of a sequential text such as this paper. Consequently, the material here presented will be made available to anyone who contacts the authors.

4. Suggestions concerning the consultation strategies and the type of learning

BivarZero was demonstrated to a number of first year students of Business Economics at the University of Bologna in order to observe their behaviour. Though this was clearly not a true test of the functionality of the hypertext, a number of technical solutions were improved thanks to our observation of the student trial.

For example, a number of possible solutions were tested with reference to the need to provide perturbations to the intuition in the phase involving the first barrier. We noted that the different solutions we tried had a different impact according to whether the subject's background was technical/business high school or the more academic *liceo*. The fading effect applied to the explanatory picture or to the lower level chart was generally more successful among students from the *liceo*. The perturbation with interactive graphics or with a text to complete with the correct phrase worked considerably better for those subjects who, having a background of technical/commercial studies, interpreted the study of Statistics in a more practical manner.

The present demonstrational/experimental state of *BivarZero* has not enabled us to formulate any real tests of the reaction to the hypertext tool in the teaching of Statistics. Nevertheless, it is our intention to assess as soon as possible the two fundamental assumptions of *BivarZero*. Firstly, the non-causality of its consultation, which is intended to be dictated by the intuitive strategies of the user, and secondly, that the hypertext tool can be very useful in contexts such as a professional or company situation in which Statistics is considered as an operative tool for the solution of concrete problems.

5. Final considerations

The teaching of technical disciplines by means of recourse to multimedia tools is seen by many as the future for both scholastic and also professional teaching. In this context, two connected considerations seem to be the order of the day where there is authoritative debate on the subject (Gardner, 1993).

The first of these is that the hypertext and the other hypermedia educational tools will enable us to construct, in the near future, laboratory environments in which, through the use of recognition and programming software, every user/learner will increasingly be able to cut to his own shape a cognitive experience in which he is actively involved. In other words, the learning pattern of each user/learner will be increasingly a function of his specific requirements, in relation to a menu of subjects and events prepared by the authors of new learning products such as the hypertext.

The second consideration concerns the consequent transformation that the role of author/educator will undergo in the planning and supply of teaching. The increasingly virtual characteristics of the hypertext, and its quality of continuous encyclopaedic expandability, will lead authors to work increasingly in integrated multi-disciplinary groups, in which the role of author will lose some of its authority over the work itself. The task of the authors will thus be far more complex in that they will have to organise the learning in a collaborative manner, taking as much account as possible of the various potential paths/requirements that exist among the readers/users. On the other hand, only a group project will be able to ensure the modular nature of education and the interconnection between different phases and subjects (Adams *et al.*, 1989).

The hypertext and, more generally, hypermediality in teaching will then be able to reveal all its potential for the organisation and inter-disciplinary fruition even of particularly technical and apparently unconnected subjects or disciplines such as those dealt with by Statistics.

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